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A SYSTEMATIC REAPPRAISAL OF THE GENUS *DIURAPHIS* AIZENBERG (HEMIPTERA: APHIDIDAE)

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Abstract.—Adult female apterae and alates of the genus *Diuraphis* Aizenberg are described and illustrated, and keys are provided for identification. *Diuraphis elymophila* G.-x. Zhang is considered a **new synonym** of *Diuraphis frequens* (Walker) and *Diuraphis muehlei* (Börner) is considered a **new synonym** of *Diuraphis noxia* (Kurdjumov). A phylogenetic analysis suggests that while the clade that contains *Diuraphis noxia* + *Diuraphis mexicana* is monophyletic, the previously recognized subgenus *Holcaphis* is paraphyletic.

Key Words: aphid, *Diuraphis, Holcaphis*

The genus *Diuraphis* was proposed in 1935 with *Brachycolus noxius* Mordvilko [= *Diuraphis noxia* (Kurdjumov)] as its type species (Aizenberg 1935). As currently defined (Remaudière and Remaudière 1997), there are 11 species in the genus referable to two generally recognized subgenera. The subgenus *Diuraphis sensu stricto* contains three species: *D. mexicana* (McVicar Baker), *D. muehlei* (Börner) and *D. noxia* (Kurjumov). The subgenus *Holcaphis* Hille Ris Lambers (1939) comprises the remaining species and includes: *D. agropyronophaga* G.-x. Zhang, *D. agrostidis* (Muddathir), *D. bromicola* (Hille Ris Lambers), *D. calamagrostis* (Ossiannilsson), *D. elymophila* G.-x. Zhang, *D. frequens* (Walker), *D. holci* (Hille Ris Lambers), and *D. tritici* (Gillette). Historically, *Diuraphis sensu stricto* differs from *Holcaphis* by the presence of a supracaudal process on the eighth abdominal tergite and usually the presence of marginal tubercles on abdominal segments II–VI (Heie 1992). Although the two subgenera of *Diuraphis* are generally recognized (Eastop and Hille Ris Lambers 1976, Remaudière and Remaudière 1997), their monophyly has not been tested.

Diuraphis was not well known until the early 20th century when outbreaks of *D. noxia* (the Russian wheat aphid) and *D. tritici* (the western wheat aphid) in Russia and the western United States, respectively, brought attention to the destructiveness of these aphids on wheat. By the late 1970's, attention was once again focused on *Diuraphis,* especially *D. noxia.* Substantial range extension of *D. noxia* was first documented in South Africa in 1978 (Dürr 1983) and in the United States in 1986 (Stoetzel 1987). This aphid spread quickly and now has been recorded throughout much of the wheat growing regions of the world. In the United States, its damage to wheat and barley was extensive and resulted in heavy crop losses in some fields (Stoetzel 1987). By 1993, *D. noxia* was a pest in 16 western states and caused cumulative losses estimated at $500–900 million dollars (Bernal et al. 1993, Morrison and Peairs 1998).

Because *D. noxia* is recognized as an economically important pest, much of the literature on *Diuraphis* has concentrated on this species. However, Zhang et al. (1991) gave a key to *Diuraphis* and discussed phylogenetic relationships. They also included the descriptions of *D. agropyronophaga* and *D. elymophila.* Kovalev et al. (1991) provided a key to the *Diuraphis* apterous viviparous females and reviewed the Russian literature. Descriptions, keys to apterae and alata, and illustrations of *Diuraphis* of Fennoscandia and Denmark were provided by Heie (1992). Halbert et al. (1992) also included keys to North American *Diuraphis.*

Apterae and alatae of the genus *Brachycolus* Buckton closely resemble *Diuraphis,* the main difference is the position of the cornicle (Heie 1992). In *Brachycolus* and most other genera of aphids, the cornicle is on the posterior portion of abdominal tergite V, whereas in *Diuraphis* the cornicle is on the posterior portion of abdominal tergite VI (Heie 1992). However, neither the relationship between *Diuraphis* and *Brachycolus* in a phylogenetic context nor the monophyly of the subgenera of *Diuraphis* have been examined.

The objectives of this paper are to: (1) redescribe, illustrate, and present keys for the identification of apterae and alatae of *Diuraphis* species; and (2) test the hypothesis that *Diuraphis* is monophyletic and comprised of two distinct subgroups (i.e., *Diuraphis* (*sensu stricto*) and *Holcaphis*).

Materials and Methods

Synoptic descriptions are taken from original descriptions, types, and identified material from the Aphidoidea collection of: Muséum National D'Histoire Naturelle (MNHN), Paris, France; National Museum of Natural History (USNM), Beltsville, MD, U.S.A.; Canadian National Collection of Insects (CNCI), Ottawa, Canada; The Natural History Museum, London, U.K. (BMNH); Institute of Zoology Academia Sinica (IZAS), Beijing, People's Republic of China, and University of Rostock Insect Collection (URIC), Sagerheide, Germany. Measurements are presented in millimeters as minimum and maximum ranges of representative specimens.

Morphological terms and structures adapted from Stoetzel et al. (1999) are used in this work. Those terms are listed below, and equivalent terms that may be found in other literature are listed in parentheses for reference: terminal process (= unguis, processus terminalis); secondary sensoria (= secondary rhinaria); cornicle (= siphunculus); fundatrix/fundatrices (= stem mother(s)); aptera/apterae (= wingless viviparous female(s)); alata/alatae (= winged viviparous female(s)); and ovipara/oviparae (= egg-laying female(s)).

The information under Specimens Examined is organized to conserve space. Abbreviations for fundatrices, apterae, alatae, oviparae, apterous males, alate males, and immatures are listed as: fund.; ap.; al.; ov.; ap. ♂; al. ♂; and imm. respectively. If a collection was made at the same locality, but on a different date as a previously listed collection, duplicated information is not repeated. For example, the documentation provided for a particular locality may be recorded as: TEXAS: Big Bend, VII-11–1978, on *Bromus unioloides* [= *Bromus catharticus*], I. M. Miller coll., (2 al.) USNM; VIII-29–1957, XI-21–1957, IV-14–1978, on *Bromus* sp., (15 ap. on 15 sl.) USNM. In this hypothetical example, the second collection was also found at Big Bend, even though "Big Bend" was not repeated. When specimens are mounted on a single slide (sl.), it is not written as such but is assumed. Bracketed ([]) text represents supplemental information by the present authors for clarification purposes or refers to the original collection data of laboratory reared specimens. Collection data that are the same except for collection date are simply listed sequentially. Host plants listed in the Specimens Examined sections are summarized in Table 2.

Table 1. Data matrix used in the cladistic analysis.

	1 1234567890	1111111112 1234567890	2222222 1245678
B. cerastii	1000110110	0000011011	0010011
B. cucubali	0000000210	1001011001	0010001
B. stellariae	0010111000	0111111011	0011111
B. asparagi	1010121100	1011101101	1000010
D. agropyronophaga	0010020310	0011111111	1011001
D. agrostidis	0001021001	1010110110	1000011
D. bromicola	0011120011	1101011111	1011110
D. calamagrostis	0000121201	1001110010	10010--
D. frequens	1001020001	1010011111	1000100
D. holci	0001010211	1110110110	1010000
D. mexicana	1111120301	1001111011	1110000
D. noxia	1112120101	1101101001	1111000
D. tritici	1002120300	0110111111	1010100

Phylogenetic analysis.—Phylogenetic analyses of *Diuraphis* and selected outgroups were conducted to test the monophyly of *Diuraphis* and infer relationships within the genus to test the validity of currently recognized subgenera of *Diuraphis* (*Diuraphis sensu stricto* and *Holcaphis*). Nine species (*Diuraphis agropyronopha* G.-x. Zhang, *Diuraphis agrostidis* (Muddathir), *Diuraphis bromicola* (Hille Ris Lambers), *Diuraphis calamagrostis* (Ossiannilsson), *Diuraphis frequens* (Walker), *Diuraphis holci* (Hille Ris Lambers), *Diuraphis mexicana* (McVicar Baker), *Diuraphis noxia* (Kurdjumov), and *Diuraphis tritici* (Gillette)) are included in the present analysis. Examination of type material of *Diuraphis muehlei* (Börner) and *Diuraphis elymophila* Zhang revealed that those species are junior synonyms of *D. noxia* and *D. frequens*, respectively.

Brachycolus stellariae (Hardy), *Brachycolus cerastii* (Kaltenbach), *Brachycolus cucubali* (Passerini), and *Brachycorynella asparagi* (Mordvilko) are included as outgroups to provide a context in which to test the proposed monophyly of *Diuraphis sensu lato*. *Diuraphis* is suspected to be closely related to *Brachycolus* and *Brachycorynella*. Members of these three currently recognized genera were referable to *Brachycolus* (Shaposhnikov 1964). Heie (1992) also noted *Brachycorynella* was similar to *Brachycolus*.

Characters: Thirty morphological characters were examined. Two characters proved to be autapomorphic and were excluded from the final data set as parsimony uninformative. Of the remaining 28 characters, 25 were coded as binary while three were treated as non-additive multistate characters. Unknown or indeterminable character states were coded as missing data. Character descriptions are outlined below and the final data matrix is presented in Table 1.

Apterous viviparous female (excluding the fundatrix)

Head

1. Tips of median dorsal head setae: pointed or tapered (0); blunt (1).

Antennae

2. Base of scape with slight posterior-lateral protuberance: absent (0); present (1).
3. Antennal tubercle shape: undeveloped or flat (0); moderately developed or slightly raised (1).
4. Antennal segment I: entirely pigmented (0); pigmented medially (1); pale (2).
5. Antennal segment II venter: usually smooth (0); usually with some imbrications (1).

6. Antennal segment III: entirely pigmented except for base (0); pigmentation reduced to base or apex (1); pale (2).
7. Antennal segment III: imbricated throughout (0); partly imbricated (1).
8. Length of antennal segment IV compared to length of segment V: segment IV usually longer than segment V (0); segment IV usually shorter than segment V (1); length of segment IV subequal to length of segment V (2); length of segment IV variable when compared to segment V (3).
9. Length of antennal segment III compared to length of antennal segment IV +V: shorter (0); longer (1).

Mouthparts

10. Ultimate rostral segment accessory setae: present (0); absent (1).
11. Length of base of antennal segment VI compared to ultimate rostral segment: usually shorter or subequal (0); longer (1).
12. Number of setae anterolateral to postclypeus: 2–3 (0); 1 (1).

Thorax

13. Lateral prothoracic tubercles: present at least sometimes (0); absent (1).
14. Protibiae: not uniformly colored (0); uniformly colored (1).
15. Metafemur: not uniformly colored (0); uniformly colored (1).

Abdomen

16. Large polygonal dorsal abdominal reticulation: present (0); absent (1).
17. Intersegmental sclerites: present (0); absent (1).
18. Lateral abdominal tubercles: present at least sometimes (0); absent (1).
19. Apical flange of cornicle: present (0); absent (1).
20. Cornicle with associated basal sclerite: present (0); absent (1).
21. Cornicle position: anterior to stigmal pore VI (0); level or posterior to stigmal pore VI (1).
22. Dorsum of abdominal segment VIII: usually not raised medially (0); raised medially (1).
23. Cauda: apically rounded (0); apically pointed (1).
24. Mid-ventral caudal spicules: individually separate (0); connected (1)
25. Length of cauda compared to length of hind tarsus II: longer (0); shorter or approximately equal (1).

Alate viviparous females

Antennae

26. Antennal segment IV secondary sensoria: usually present (0); usually absent (1).
27. Length of antennal segments IV + V compared to antennal segment III: longer (0); shorter or subequal (1).

All phylogenetic analyses were performed using PAUP* (Swofford 2001). Maximum parsimony (MP) analyses were conducted using branch-and-bound searches, and bootstrap analyses involved 1,000 replicates of branch-and-bound searching. In the initial MP analyses, all characters were treated as unordered and as having equal weights. In subsequent analyses, the successive approximations approach to character weighting (SACW) was used to select the most cladistically reliable topology (Farris 1969). For the SACW analysis, characters were weighted based on the rescaled consistency index.

Phylogenetic Results and Discussion

MP analysis generated 16 equally most parsimonious topologies all with a tree length of 83, consistency index (CI) of 0.37, retention index (RI) of 0.43, and rescaled consistency index (RC) of 0.16. Three iterations of SACW with characters weighted based on the rescaled consistency index resulted in a single most parsimonious topology (Fig. 1) with a tree length of 14.28, CI of 0.63, RI of 0.75, and RC of 0.47. Bootstrap analysis of the unweighted data set produced relatively low support values, with only two nodes recovered in greater than 50% of the replicates.

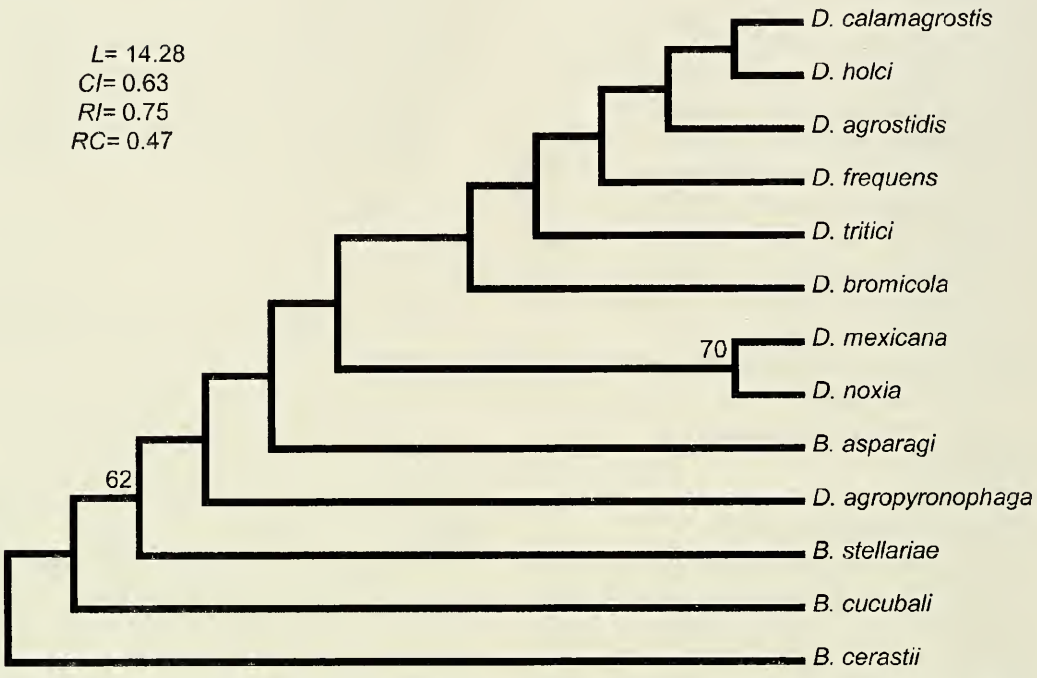


Fig. 1. Maximum parsimony topology resulting from three iteration of successive weighting and branch-and-bound analysis. Node labels indicate bootstrap proportions obtained from an analysis of the unweighted matrix. *L* = Length, *CI* = Consistency Index, *RI* = Retention Index, *RC* = Rescaled Consistency Index.

The most parsimonious tree presented in Fig. 1 conflicts with current taxonomic concepts of *Diuraphis* in that the genus is not recovered as a well-supported monophyletic group. The recovery of *B. asparagi* within the *Diuraphis* clade is problematic, but not entirely unprecedented. *B. asparagi* shares many similarities with *Diuraphis* species and has been grouped with other species of *Diuraphis* is previous studies (e.g., Shaposhnikov 1964). The relative position of the cornicle with respect to stigmal pore VI (character 21), although lacking strong bootstrap support, is potentially synapomorphic for these taxa.

Regarding proposed subgeneric divisions of *Diuraphis,* the data examined in this study provides support for *Diuraphis sensu stricto* (*D. mexicana* + *D. noxia*) which was recovered with bootstrap support of 70%. This clade is united by a slight posterior-lateral protuberance on the base of the scape and a medially raised dorsal surface of abdominal segment VIII. The grouping of *D. mexicana* + *D. noxia* carries interesting biogeographic implications since *D. mexicana* and *D. noxia* are of Nearctic and Palearctic origin, respectively.

The remaining *Diuraphis* species, however, were not recovered as a monophyletic sister-group to the *D. mexicana* + *D. noxia* clade and thus, it would be inappropriate to treat this as a subgeneric division of *Diuraphis sensu lato.* Therefore, although there is support for *Diuraphis sensu stricto,* we conclude that it is not instructive to recognize the proposed subgenus *Holcaphis* (e.g., Eastop and Hille Ris Lambers 1976; Remaudière and Remaudière 1997), since it most likely represents a non-monophyletic

grouping of the remaining *Diuraphis* species.

Diagnosis of the Genus *Diuraphis*

Diuraphis is characterized by an elongate body, relatively short antennae, antennal tubercles low or weakly developed, abdominal dorsum usually without pigmented sclerites anterior to segment VI but some species have intersegmental abdominal sclerites, cornicles inconspicuous and usually without an apical flange, and first tarsal segments in adults with 3–3–2 setae. Some species have abdominal tubercles, spinal supracaudal process present or absent, and dorsal setae occasionally spatulate. Most species produce wax. *Diuraphis* species generally are associated with leaves of various cultivated and wild grasses (Poaceae).

Key to Apterae and Alatae *Diuraphis* (alatae of *D. calamagrostis* not included due to insufficient material)

1. Abdominal segment VIII supracaudal process present as a well developed fingerlike projection (Fig. 9D); cornicle with apical flange; lateral prothoracic tubercles and abdominal marginal tubercles present . . . . . *D. noxia*
– Abdominal segment VIII supracaudal process either absent, slightly raised, or present as a conical or triangular protuberance but not fingerlike; cornicle without apical flange; lateral prothoracic tubercles and marginal tubercles present or absent 2
2. Prothoracic tubercles or marginal tubercles present 3
– Prothoracic tubercles or marginal tubercles absent 4
3. Length of setae on antennal segment III approximately ½ the diameter of the base; apterae with supracaudal process on abdominal segment VIII present as a conical or triangular protuberance (Fig. 8D), abdomen without intersegmental sclerites, cauda triangular with pointed apex . . . . . *D. mexicana*
– Length of setae on antennal segment III subequal to the diameter of the base; apterae without supracaudal process on abdominal segment VIII, abdomen with intersegmental sclerites, cauda parallel sided with bluntly rounded apex . . . . . *D. calamagrostis* (apterae only) (in part)
4. Ultimate rostral segment with a pair of accessory setae 5
– Ultimate rostral segment without accessory setae 6
5. Length of antennal segment III shorter than antennal segments IV + V; ultimate rostral segment approximately 2 times as long as wide at base . . . . . *D. agropyronophaga*
– Length of antennal segment III subequal to longer than antennal segments IV + V; ultimate rostral segment approximately 3 times as long as wide at base . . . . . *D. tritici*
6. Abdomen with intersegmental sclerites, although sclerites may be extremely reduced in some alata; length of hind tarsus II shorter or subequal to length of cauda 7
– Abdomen without intersegmental sclerites; length of hind tarsus II longer than length of cauda 9
7. Legs stout, e.g., greatest width of hind tibiae subequal or wider than the length of penultimate antennal segment; rostrum length subequal to width at base . . . . . *D. calamagrostis* (apterae only) (in part)
– Legs more slender, e.g., greatest width of hind tibiae less than the length of penultimate antennal segment; rostrum longer than width at base 8
8. Antennal segment III usually longer than segment IV + V, occasionally subequal to segment IV+V; cornicles short, approximately ¼ to ⅓ the length of the cauda . . . . . *D. holci*
– Antennal segment III usually shorter than segment IV + V, occasionally subequal to segment IV+V; cornicles very short, porelike, approximately $\frac{1}{10}$ to $\frac{1}{5}$ the length of the cauda . . . . . *D. agrostidis*
9. Cornicle unpigmented, porelike, $\frac{1}{20}$ to $\frac{1}{10}$ the length of the cauda; dorsal sclerites on abdominal segment VII absent or reduced to a few scattered polygonally sclerotized areas . . . . . *D. bromicola*
– Cornicle pigmented, short but elongate, $\frac{1}{5}$ to ⅓ the length of the cauda; dorsal sclerites on abdominal segment VII well developed, extending nearly to spiracle . . . . . *D. frequens*

Diuraphis agropyronophaga G.-x. Zhang (Fig. 2)

Diuraphis (*Holcaphis*) *agropyronophaga* G.-x. Zhang, 1991:327; Zhang et al.1991: 123; Remaudière and Remaudière 1997: 91

Type material.—Aptera holotype, No. 6324-1-1-2, on *Agropyron* sp., Nei Mongol Automous Region, Fregzhen County, 19-VI-1976, G.-x. Zhang and T.-s. Zhong coll., not seen. We have studied a single paratype

Table 2. Host plants of *Diuraphis*. The following host plant information represents a summary of those plants listed in the Specimens Examined sections. Although some of the host data may represent aberrant hosts, they are included for reference purposes. When common names for various hosts were used, they are recorded as such on the list and the scientific name is added in parentheses for cross-reference. Botanical names listed in the collection data were checked against the Integrated Taxonomic Information System (Anonymous 2004a), The International Plant Names Index (Anonymous 2004b), and the National Genetic Resources Program, Germplasm Resources Information Network (Anonymous 2004c).

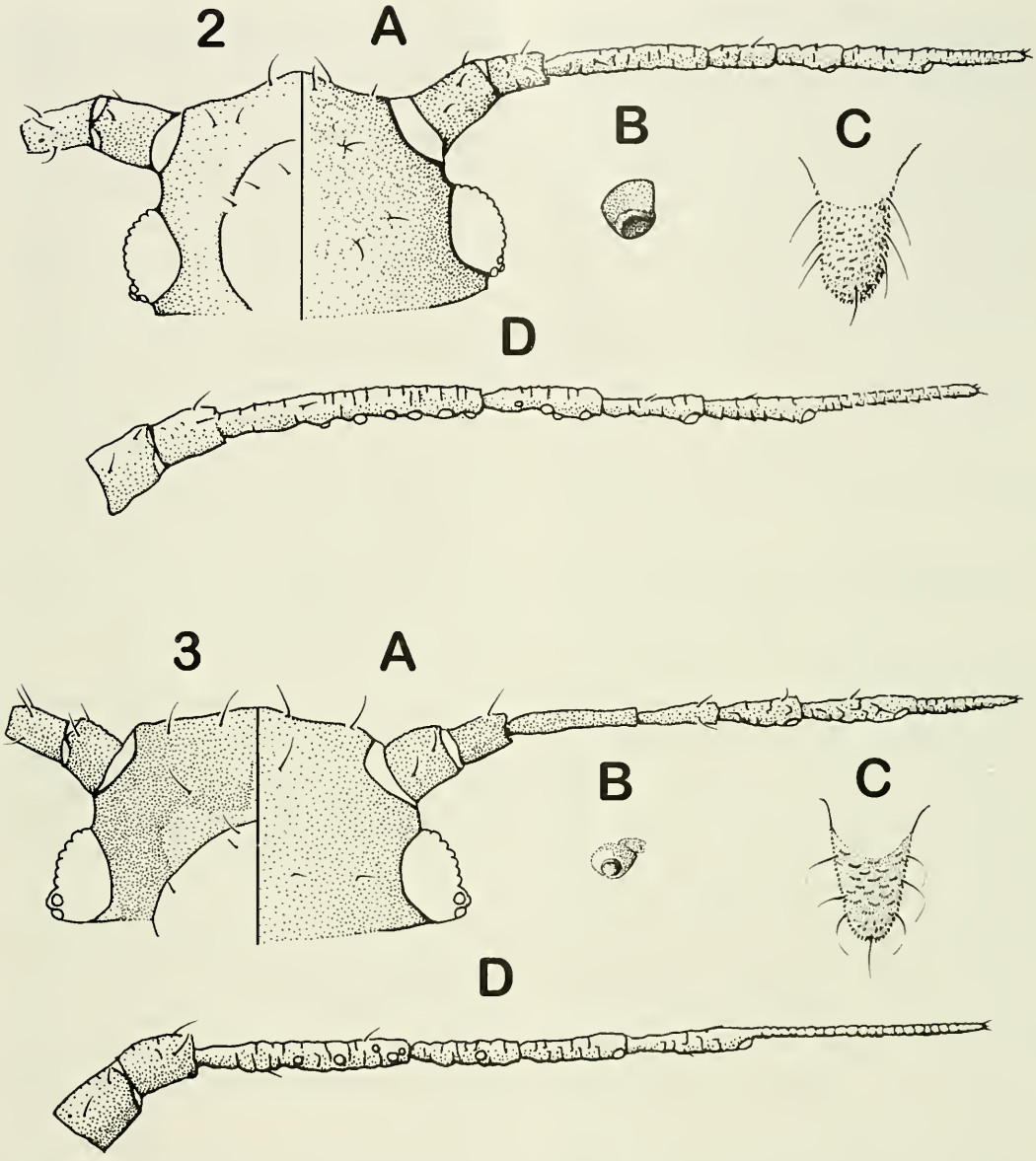
Agrostis stolonifera
Diuraphis agrostidis Muddathir
Agropyron sp.
Diuraphis agropyronophaga G.-x. Zhang
Diuraphis noxia (Kurdjumov)
Avena sp.
Diuraphis tritici (Gillette)
Barley (see *Hordeum* sp.)
Bromus catharticus Vahl
Diuraphis mexicana (McVicar Baker)
Diuraphis noxia (Kurdjumov)
Bromus carinatus Hook. & Arn.
Diuraphis mexicana (McVicar Baker)
Diuraphis noxia (Kurdjumov)
Bromus inermis Leyss.
Diuraphis bromicola (Hille Ris Lambers)
Bromus marginatus Nees ex Steud.
Diuraphis mexicana (McVicar Baker)
Diuraphis tritici (Gillette)
Bromus polyanthus Scribn.
Diuraphis mexicana (McVicar Baker)
Bromus tectorum L.
Diuraphis noxia (Kurdjumov)
Bromus sp.
Diuraphis mexicana (McVicar Baker)
Calamagrostis lanceolata
Diuraphis calmagrostis (Ossiannilsson)
Calamagrostis purpurea
Diuraphis calmagrostis (Ossiannilsson)
Downy brome (see *Bromus tectorum*)
Echinochloa crus-galli (L.) Beauv.
Diuraphis frequens (Walker)
Elymus dahuricus Turcz. ex Griseb.
Diuraphis frequens (Walker)

Table 2. Continued.

Elymus glaucus Buckl.
Diuraphis frequens (Walker)
Elymus sp.
Diuraphis tritici (Gillette)
Elytrigia repens var. *repens*
Diuraphis frequens (Walker)
Holcus lanatus L.
Diuraphis holci (Hille Ris Lambers)
Holcus mollis L.
Diuraphis holci (Hille Ris Lambers)
Hordeum murinum L.
Diuraphis noxia (Kurdjumov)
Hordeum vulgare L.
Diuraphis holci (Hille Ris Lambers)
Diuraphis noxia (Kurdjumov)
Hordeum sp.
Diuraphis noxia (Kurdjumov)
Mountain brome (see *Bromus marginatus*)
Oats (see *Avena* sp.)
Pascopyrum smithii (Rydb.) A. Love
Diuraphis tritici (Gillette)
Phleum pratense L.
Diuraphis noxia (Kurdjumov)
Phleum pratense ssp. *nodosum* (L.) Arcang.
Diuraphis frequens (Walker)
Diuraphis noxia (Kurdjumov)
Phleum sp.
Diuraphis noxia (Kurdjumov)
Quack grass (see *Elytrigia repens* var. *repens*)
Triticum aestivum L.
Diuraphis noxia (Kurdjumov)
Triticum sp.
Diuraphis noxia (Kurdjumov)
Diuraphis tritici (Gillette)
Wheat (see *Triticum* sp.)

slide deposited in IZAS with left label, "9921–1–1 Agropyron 90.VI.1" and right label, "PARATYPES, Holcaphis agropyronophaga ZHANG 16-VI-1990 Ningxia China." Additional paratypes listed in Zhang et al. (1991).

Field features.—Aptera grayish white,



Figs. 2–3. 2, *Diuraphis agropyronophaga.* A, Right side, aptera dorsum of head and antennal segments; left side, aptera venter of head and antennal segments I–II. B, Antenna of alata. C, Cornicle of aptera. D, Cauda of aptera. 3, *D. agrostidis.* A, Right side, aptera dorsum of head and antennal segments; left side, aptera venter of head and antennal segments I–II. B, Antenna of alata. C, Cornicle of aptera. D, Cauda of aptera.

covered with white powder (Zhang et al. 1991).

Recognition characters.—*Aptera:* Body length 2.220–2.232; width through eyes, 0.378. Antenna (Fig. 2A) shorter than body; segment III 0.150–0.216 long; IV 0.066–0.102 long; V 0.066–0.078 long; base of VI 0.084–0.108 long; terminal process, 0.084–0.132 long. Head sclerotized, smooth, without spinulation; longest dorsal head setae subequal to width of antennal segment III. Rostrum extending to mesocoxae; ultimate segment 0.108–0.114 long, approximately 2 times as long as wide at base, subequal to

hind tarsal segment II, with 2 accessory setae. Pronotum without marginal tubercles. Hind tibia 0.468–0.570 long; hind tarsus II 0.114 long. Abdomen smooth with ventral surface spiculose, dorsal surface spiculose on segments VI-VIII, with sclerite on segment VII-VIII; marginal abdominal tubercles and supracaudal process absent. Cornicle (Fig. 2B) pigmented, short, 0.030 long, apical flange undeveloped; without associated basal sclerite. Cauda (Fig. 2C) 0.138 long, elongate, triangular, with slight medial constriction, 6–7 lateral setae.

Alata: Body length 1.416; width through eyes 0.390–0.342. Antenna (Fig. 2D) shorter than body; segment III 0.246–0.228 long, with 6–7 secondary sensoria restricted to approximately half circumference of segment; IV, 0.102 long, with 2–4 secondary sensoria; V, 0.090–0.096 long, without secondary sensoria; base of VI, 0.102–0.114 long; terminal process, 0.138 long. Dorsal head setae longer than width of antennal segment III. Rostral length and setae similar to apterous female, ultimate segment 0.102–0.108 long with 2 accessory setae. Pronotum without marginal tubercles. Hind tibia 0.600–0.618 long; hind tarsus II 0.126–0.132 long. Abdominal tergum without patches or bands, surface sculpturing similar to aptera, abdominal tergite VIII with 3–5 setae; abdominal marginal tubercles and supracaudal process absent. Cornicle short, smooth, 0.024 long, similar to aptera. Cauda 0.120–0.120 long, similar to aptera, with 6 lateral setae.

Notes.—Although Zhang (1991) illustrates *D. agropyronophaga* with a slightly raised area on abdominal tergite VIII, this structure was not discernable on the specimens we examined.

Diuraphis agropyronophaga resembles *D. tritici.* However, the ultimate rostral segment is shorter than *D. tritici* (approximately 2 times as long as wide at the base versus approximately 3 times as long as wide at the base for *D. tritici*). Also, in *D. agropyronophaga,* the length of antennal segment III is shorter than antennal segments IV + V whereas the length of antennal segment III is subequal to longer than antennal segments IV + V in *D. tritici.* See also Notes section for *D. tritici.*

There has been some confusion in the literature concerning the publication date of *D. agropyronophaga* (Zhang 1991). The date was listed by Remaudière and Remaudière (1997) as 1990, the date that appears in the title of Zhang's (1991) publication. However, this work was not published until May 1991 (as printed on the publication). A description of *D. agropyronophaga* was also listed as "sp. nov." in Zhang et al. (1991), but, because the actual time of issuance has not been determined, that work would be listed as the last day in 1991.

Specimens examined.—CHINA: Ningxia, ex *Agropyron* sp., IZAS: 16-VI-1990 (2 ap. paratypes, 2 al. paratypes, 2 alatoid imm. labeled "PARATYPES").

Diuraphis agrostidis (Muddathir) (Fig. 3)

Holcaphis agrostidis Muddathir 1965:477.
Diuraphis (*Holcaphis*) *agrostidis*: Eastop and Hille Ris Lambers 1976:175; Remaudière and Remaudière 1997:91.

Type material.—Holotype, morphotypes, and paratypes deposited in BMNH (Muddathir 1965); not seen.

Field features.—Aptera yellow green with white powder; head dark, almost black; antennae, legs, and cauda dark (Heie 1992).

Recognition characters.—*Aptera:* Body length 1.470–2.100; width through eyes 0.318–0.384. Antenna (Fig. 3A) shorter than body; segment III 0.090–0.162 long; IV 0.060–0.084 long; V 0.072–0.084 long; base of VI 0.066–0.084 long; terminal process 0.102–0.120 long. Head sclerotized, smooth, without spinulation; longest dorsal head setae longer than width of antennal segment III. Rostrum ending before mesocoxae; ultimate segment 0.066–0.084 long, approximately 1.5 times as long as wide at base, shorter than hind tarsal segment II,

without accessory setae. Pronotum without marginal tubercles. Hind tibia 0 .390–0.420 long; hind tarsus II 0.108–0.120 long. Abdomen smooth with ventral surface spiculose, dorsal surface spiculose on segments VI-VIII, with small pleural and intersegmental sclerites, large sclerites on segments V-VIII; abdominal marginal tubercles and supracaudal process absent. Cornicle (Fig. 3B) slightly pigmented, short, 0.018–0.024 long, apical flange undeveloped; with associated basal sclerite. Cauda (Fig. 3C) 0.120–0.144 long, elongate, triangular with rounded apex, 6 lateral setae and usually one preapical seta.

Alata: Body length 1.860–1.902; width through eyes 0.360–0.372. Antenna (Fig. 3D) shorter than body; segment III 0.192–0.198 long, with 4–5 secondary sensoria restricted to approximately half circumference of segment; IV 0.078–0.102 long, with 0–1 secondary sensoria; V 0.090–0.102 long, without secondary sensoria; base of VI 0.102–0.108 long; terminal process 0.192–0.210 long. Dorsal head setae subequal to width antennal segment III. Rostral length and setae similar to apterous female, ultimate segment 0.060–0.072 long without accessory setae. Pronotum without marginal tubercles. Hind tibia 0.540–0.636 long; hind tarsus II 0.108–0.114 long. Abdominal surface sculpturing and sclerotization similar to aptera, abdominal tergite VIII with 3–5 setae; abdominal marginal tubercles and supracaudal process absent. Cornicle short, smooth, 0.018 long, similar to aptera. Cauda 0.120 long, similar to aptera.

Notes.—*Diuraphis agrostidis* most closely resembles *D. holci.* Apterae and alatae of *D. agrostidis* have intersegmental sclerites that are larger than the adjacent spiracle and associated sclerotized area, and antennal segment III is usually shorter than antennal segments IV + V. Conversely, apterae and alatae of *D. holci* have intersegmental sclerites that are subequal or smaller than adjacent spiracle and associated sclerotized and antennal segment III is usually longer than antennal segments IV + V. The host of *D. agrostidis* is *Agrostis stolonifera* L. (Muddathir 1965, Heie 1992) whereas the host of *D. holci* are *Holcus* spp. See also Notes section for *D. bromicola, D. frequens,* and *D. holci.*

Specimens examined.—UNITED KINGDOM: SCOTLAND: Frazerburgh, ex grass, H.L.G.S. coll., BMNH: 13-VIII-1959 (8 ap., 2 imm.). ENGLAND: Northumberland, Newcastle, King's College, ex *Agrostis stolonifera,* K. Muddathir coll., BMNH: 8-?-1963 (2 al.).

Diuraphis bromicola (Hille Ris Lambers) (Fig. 4)

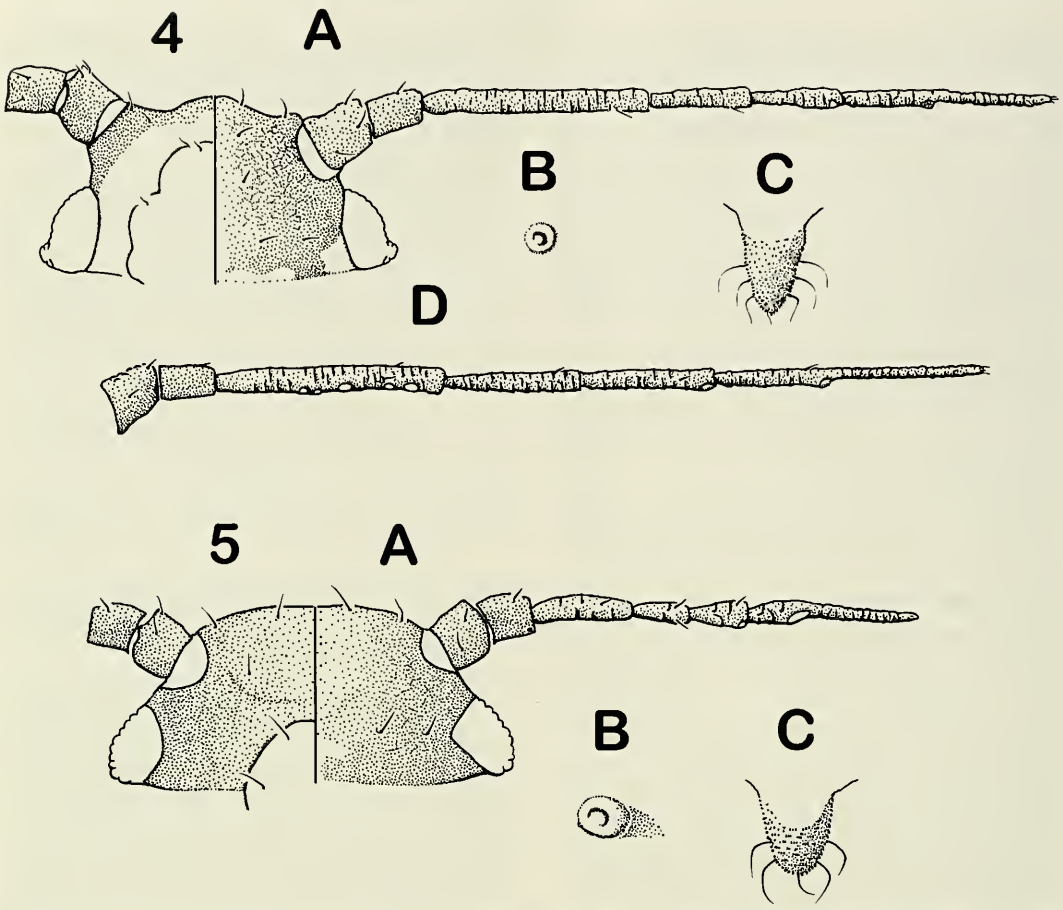
Holcaphis bromicola Hille Ris Lambers 1959:281.

Diuraphis (*Holcaphis*) *bromicola*: Eastop and Hille Ris Lambers 1976:175; Remaudière and Remaudière 1997:91.

Type material.—Two cotype slides seen. One slide with left label "*Holcaphis bromicola* nov. spec cotypes Det. D.H.R.L." and right label "N. Germany Pl. *Bromus inermis* Loc. Leipzig Date Oct. 1956 Leg. Mühle BM1984-340 "(BMNH). Another slide with left label "*Holcaphis bromicola* nov. spec cotypes Det. D.H.R.L." and right label "N. Germany Pl. *Bromus inermis* Loc. Leipzig Date 20-VI-1957 Leg. Mühle BM1984-340 "(BMNH). Cotypes of *D. bromicola* were originally deposited in the collection of Hill Ris Lambers (1959) but are presently in BMNH.

Field features.—Oviparous female very light green with grey wax-powder; alata similar to ovipara but darker with less powder, head and thorax black (Hille Ris Lambers 1959).

Recognition characters.—*Aptera:* Body length 1.950–2.100; width through eyes 0.348–0.360. Antenna (Fig. 4A) shorter than body; segment III 0.204–0.246 long; IV 0.096–0.108 long; V 0.090–0.102 long; base of VI 0.096–0.108 long; terminal process, 0.096–0.126 long. Head sclerotized, smooth, without spinulation; longest dorsal head setae shorter than width of antennal



Figs. 4–5. 4, *Diuraphis bromicola.* A, Right side, aptera dorsum of head and antennal segments; left side, aptera venter of head and antennal segments I–II. B, Antenna of alata. C, Cornicle of aptera. D, Cauda of aptera. 5, *D. calamagrostis.* A, Right side, aptera dorsum of head and antennal segments; left side, aptera venter of head and antennal segments I–II. B, Cornicle of aptera. C, Cauda of aptera.

segment III. Rostrum ending before mesocoxae; ultimate segment 0.072 long, approximately 1.5 times as long as wide at base, shorter than hind tarsal segment II, without accessory setae. Pronotum without marginal tubercles. Hind tibia 0 .552–0.630 long; hind tarsus II 0.132–0.144 long. Abdomen smooth with ventral surface spiculose, dorsal surface spiculose on segments VI-VIII, small sclerites on segment VII and large sclerite on VIII; abdominal marginal tubercles and supracaudal process absent. Cornicle (Fig. 4B) very short, porelike, 0.006–0.012 long, unpigmented. Cauda (Fig. 4C) 0.108–0.114 long, elongate, triangular with rounded apex, 4–6 lateral setae.

Alata: Body length 1.650–1.818; width through eyes 0.330–0.384. Antenna (Fig. 4D) shorter than body; segment III 0.252–0.276 long, with 3–5 secondary sensoria restricted to approximately half circumference of segment; IV 0.138–0.162 long, with 0–1(usually absent) secondary sensoria; V 0.120–0.144 long, without secondary sensoria; base of VI 0.108–0.126 long; terminal process 0.150–0.162 long. Dorsal head setae shorter than width antennal segment III. Rostral length and setae similar to apterous female, ultimate segment 0.060–

0.072 long without accessory setae. Pronotum without marginal tubercles. Hind tibia 0.642–0.744 long; hind tarsus II 0.132–0.150 long. Abdominal surface sculpturing and sclerotization similar to aptera, abdominal tergite VIII with 4 setae; abdominal marginal tubercles and supracaudal process absent. Cornicle very short, porelike, 0.006–0.012 long, unpigmented, similar to aptera. Cauda 0.102–0.114 long, similar to aptera.

Notes.—The original species description of *D. bromicola* was based upon oviparae, alate viviparae, and apterous males (Hille Ris Lambers 1959). The present description of the apterous female is the first time this stage of *D. bromicola* has been described.

Diuraphis bromicola most closely resembles *D. agrostidis, D. frequens,* and *D. holci* but can be distinguished by the presence of porelike, unpigmented cornicles. *Diuraphis agrostidis, D. frequens,* and *D. holci* all have pigmented cornicles. Aptera and alata of *D. bromicola* also can be distinguished from *D. agrostidis* and *D. holci* by the absence of intersegmental sclerites hind tarsus II is longer than the cauda. *Diuraphis agrostidis* and *D. holci* both have intersegmental sclerties and hind tarsus II is shorter than the cauda. Aptera and alata of *D. bromicola* can be distinguished from those of *D. frequens* by the reduced dorsal sclerite on abdominal segment VII. In *D. frequens* this sclerite is well developed. See also Notes section for *D. agrostidis, D. frequens,* and *D. holci.*

Specimens examined.—GERMANY: Leipzig, ex *Bromus inermis,* Mühle, BMNH: X-1956 (4 ov. labeled "cotypes"); 20-VI-1957 (2 al. labeled "cotypes"); Leipzig, ex *Bromus inermis* BMNH: 12-VII-1959 (2 ap., 2 al.). RUSSIA: Kursk, ex *Bromus inermis,* Agarvonova, BMNH: VII-1959 (2 al.).

Diuraphis calamagrostis (Ossiannilsson) (Fig. 5)

Holcaphis calamagrostis Ossiannilsson 1959:25.

Diuraphis (Holcaphis) calamagrostis: Eastop and Hille Ris Lambers 1976:175; Remaudière and Remaudière 1997:91.

Type material.—Holotype and paratypes deposited in the collection of the Institute of Plant Pathology and Entomology, Uppsala, Sweden (Ossiannilsson 1959); however, we have studied a single paratype slide deposited in BMNH. The paratype slide examined has left label "*Holcaphis calamagrostis* Ossiannilsson apterae paratypes BM 1984–340 Det. Ossiannilsson"; right label "N. Sweden Pl. *Calmagrostis purpurea* Loc. Jälla Vaksala date 1-VII-1952 Leg. Ossiannilsson 3317" (BMNH).

Field features.—Aptera pale yellow, head, antenna and legs fuscous; alata similar to aptera but thorax entirely fuscous, abdominal segments II-VI occasionally with large dark pigmented marginal sclerites (Ossiannilsson 1959).

Recognition characters.—*Aptera:* Body length 1.566–2.538; width through eyes 0.270–0.420. Antenna (Fig. 5A) shorter than body, 5- or 6-segmented; on 5-segmented specimens, segment III 0.114–0.174 long; IV 0.030–0.072 long; base of V 0.060–0.090 long; terminal process 0.078–0.126 long; on 6-segmented specimens, segment III 0.096–0.150 long; IV 0.054–0.078 long; V 0.060–0.072 long; base of VI 0.066–0.084 long; terminal process 0.114–0.138 long. Head sclerotized, smooth, without spinulation; longest dorsal head setae subequal to width of antennal segment III. Rostrum extending just past procoxae; ultimate segment 0.054–0.072 long, subequal to width at base, shorter than hind tarsal segment II, occasionally with a single accessory seta. Pronotum with or without marginal tubercles. Hind tibia 0.288–0.510 long; hind tarsus II 0.090–0.126 long. Abdomen smooth with ventral surface spiculose, dorsal surface spiculose on segments VI-VIII, with small pleural and intersegmental sclerites, large sclerites on segments VI-VIII and occasionally a small sclerite on segment V; marginal tu-

bercles present or absent; supracaudal process absent. Cornicle (Fig. 5B) short, 0.012–0.024 long, with associated basal sclerite. Cauda (Fig. 5C) 0.096–0.138 long, elongate, parallel-sided to slightly triangular with rounded apex, 4–6 lateral setae and sometimes one preapical seta.

Alata: Not seen. See Ossiannilsson (1959) and Heie (1992) for description.

Notes.—The presence of abdominal marginal tubercles in *D. calamagrostis* may be variable. Kovalev et al. (1991) listed these structures as present in *D. calamagrostis*; conversely, Heie (1992) placed this species in the *Holcaphis* group defined in part by the "normal absence of marginal tubercles from abd. segm. II–VI." Ossiannilsson's (1959) description of the aptera indicates the presence of marginal abdominal tubercles. However, in his diagnosis section, he states "the normal presence of marginal tubercles on some of the abdominal segments" as a diagnostic character. This suggests that the marginal tubercles may not always be present. Examination of a single slide containing four paratypes revealed three of the specimens did not exhibit marginal abdominal tubercles and one of the specimens exhibited prominent marginal abdominal tubercles. The paratype that exhibited abdominal tubercles also had pronotal tubercles. The remaining paratypes that did not have abdominal tubercles, likewise did not have pronotal tubercles. In an additional slide of *D. calamagrostis* determined by Ossiannilsson, all eight determinable adults had abdominal marginal tubercles. Pronotal marginal tubercles were not visible in all specimens.

Diuraphis calamagrostis may be confused with other species of *Diuraphis* with intersegmental abdominal sclerites (*D. agrostidis* and *D. holci*), however, the rostrum of *D. calamagrostis* extends only just past the procoxae. In *D. agrostidis* and *D. holci,* the rostrum extends to the mesocoxae. In addition, the ultimate segment in *D. calamagrostis* is subequal to the width at its base. In *D. agrostidis* and *D. holci,* the rostrum is longer than the width at its base.

Specimens examined.—SWEDEN: Solna:, ex *Calamagrostis lanceolata,* Ossiannilsson, BMNH: 28-VIII-1948 (8 ap., 3 imm., 1 indeterminable); Jälla Vaksala,, ex *Calamagrostis purpurea,* Ossiannilsson BMNH: 1-VII-1952 (4 ap. labeled "paratypes").

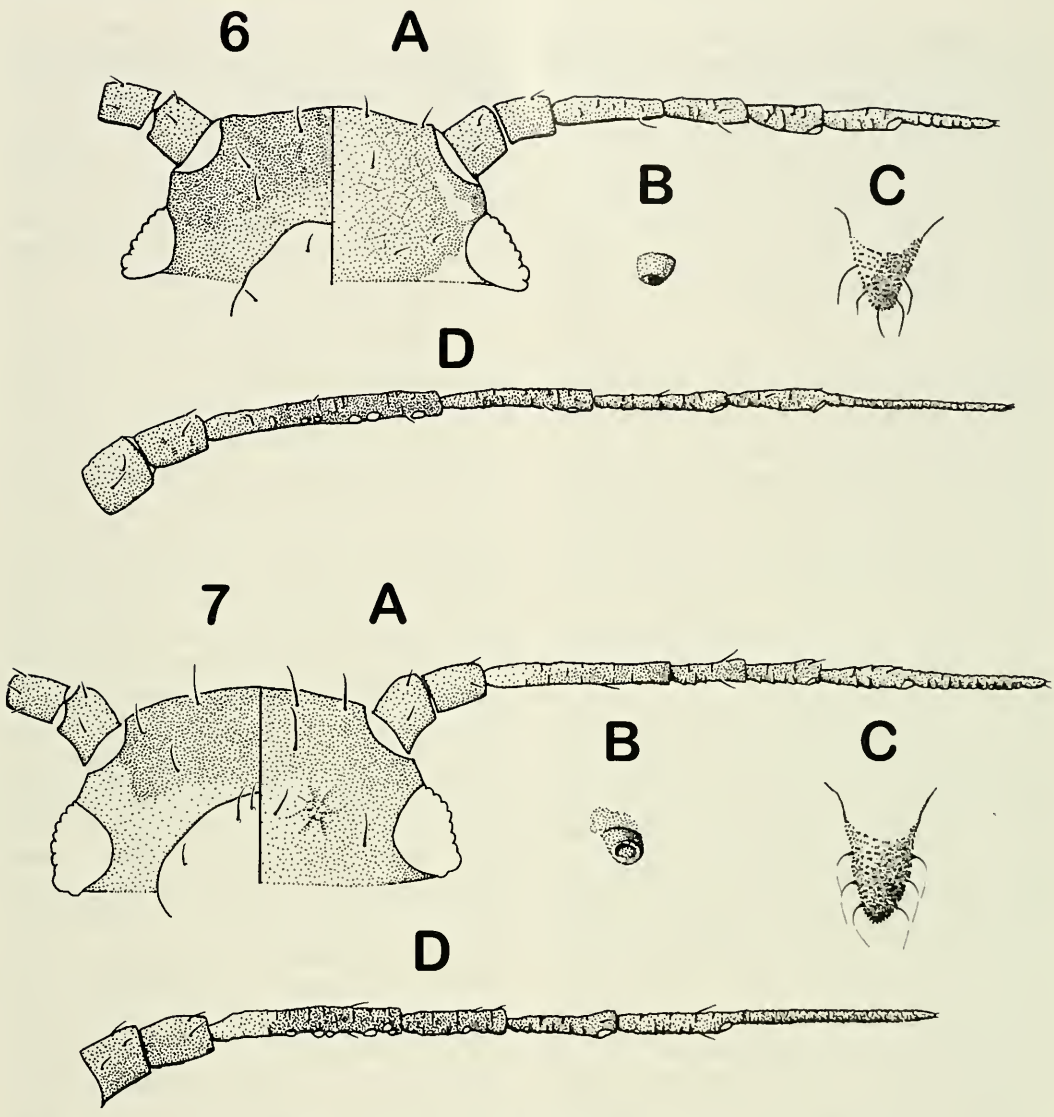
Diuraphis frequens (Walker)
(Fig. 6)

Aphis frequens Walker 1848:2219.
Brachycolus korotnewi Mordvilko 1901: 325; Hille Ris Lambers 1939:97 [synonymy with *Holcaphis frequens* (Walker)]
Holcaphis frequens: Hille Ris Lambers 1939:97.
Diuraphis (Holcaphis) frequens: Eastop and Hille Ris Lambers, 1976:176; Remaudière and Remaudière 1997:91.
Diuraphis (Holcaphis) elymophila G.-x. Zhang 1991:327; Zhang et al., 1991:125. **New synonymy**.

Type material.—The type depository for *Aphis frequens* was recorded as BMNH (Hille Ris Lambers 1939). The type specimens were not seen. Walker's (1848) original description is based on oviparae and apterous males. Type material for *Brachycolus korotnewi* is unknown. Type depository for *Diuraphis elymophila* is IZAS, holotype and five paratypes seen.

Field features.—Aptera geen with dark green head; antennae, legs and cauda black fuscous (Hille Ris Lambers 1939), cornicles brown (Heie 1992), covered with gray wax-powder (Hille Ris Lambers 1939). Ovipara dark green, somewhat glaucous, mottled with yellow, powdered with white; eyes dark red; antenna black, yellow at base; legs dull yellow, tarsi and tips of tibiae black (Walker 1848). Adult male wingless, darker than ovipara; antenna black (Walker 1848).

Recognition characters.—*Aptera:* Body length 1.560–2.070; width through eyes 0.342–0.378. Antenna (Fig. 6A) shorter



Figs. 6–7. 6, *Diuraphis frequens.* A, Right side, aptera dorsum of head and antennal segments; left side, aptera venter of head and antennal segments I–II. B, Antenna of alata. C, Cornicle of aptera. D, Cauda of aptera. 7, *D. holci.* A, Right side, aptera dorsum of head and antennal segments; left side, aptera venter of head and antennal segments I-II. B, Antenna of alata. C, Cornicle of aptera. D, Cauda of aptera.

than body, 6-segmented; segment III 0.108–0.192 long; IV 0.072–0.114 long; V 0.066–0.090 long; base of VI 0.066–0.102 long; terminal process 0.090–0.120 long. Head sclerotized, smooth, with faint reticulate spinulation; longest dorsal head setae less than width of antennal segment III. Rostrum extending to mesocoxae; ultimate segment 0.066–0.084 long, approximately 1.36–1.66 times as long as side at base, shorter than hind tarsal segment II, accessory setae absent. Pronotum without marginal tubercles. Hind tibia 0.420–0.600 long; hind tarsus II 0.114–0.156 long. Abdomen smooth with ventral surface spiculose, dorsal surface spiculose on segments VI–VIII, pleural and intersegmental sclerites absent, large sclerites on segments VI–

VIII; segment VIII sometimes with slight supracaudal process; abdominal marginal tubercles absent. Cornicle (Fig. 6B) equidistant from spiracular openings on abdominal segments VI and VII, pigmented, short, 0.025–0.031 long, apical flange undeveloped; without associated basal sclerite. Cauda (Fig. 6C) 0.090–0.126 long, elongate, triangular with rounded apex, 4–6 lateral setae.

Alata: Body length 1.800–2.130; width through eyes 0.360–0.372. Antenna (Fig. 6C) shorter than body; segment III 0.186–0.270 long, with 4–6 secondary sensoria restricted to approximately half circumference of segment; IV 0.138–0.180 long, with 0–2 secondary sensoria; V 0.096–0.126 long, without secondary sensoria; base of VI 0.096–0.114 long; terminal process 0.168–0.198 long. Dorsal head setae shorter than width antennal segment III. Rostral length and setae similar to apterous female, ultimate segment 0.078–0.084 long without accessory setae. Hind tibia 0.660–0.732 long; hind tarsus II 0.120–0.160 long. Abdominal surface sculpturing and sclerotization similar to aptera, abdominal tergite VIII with 4 setae; segment VIII sometimes with slight supracaudal process; lateral abdominal tubercles absent. Cornicle short, 0.031 long, similar to aptera. Cauda 0.090–0.126 long, similar to aptera.

Notes.—After examination of the type series, descriptions, and illustrations of *D. elymophila* Zhang et al. (1991), we have concluded that *D. elymophila* is a junior synonym of *D. frequens.* Zhang et al. (1991) believed *D. elymophila* differed from *D. frequens* by the length of the terminal process as compared to the base. They stated that the terminal process is 1.5 times as long as the base in *D. elymophila* which distinguishes it from *D. frequens,* and this character was used for species separation in a key (Zhang et al. 1991). The use of this character is suspect for two reasons. First, Zhang et al. (1991) stated in a subsequent couplet that contained *D. frequens,* that the terminal process was 1.66 times the length of the base. Secondly, examination of *D. frequens* specimens from the BMNH and USNM revealed that the length of the terminal process as compared to the base ranged from 1.1 to 1.7 for apterae and 1.4 to 2.0 for alatae. Heie (1992) recorded the length of the terminal process as 1.05–1.50 times the base for apterae and up to 1.75 times the base for alatae. Although the original description of *D. frequens* records *Artemisia maritima* L. (Asteraceae) as the host (Walker 1848), *D. frequens* has been recorded from other hosts including *Agropyron repens* [= *Elytrigia repens* var. *repens* (L.) Desv. ex B.D. Jackson] (Heie 1992 and BMNH and USNM slide data) and *Elymus glaucus* Buckl. (USNM slide data). *Diuraphis frequens* previously has been recorded as distributed in Mongolia (Heie 1992) and is reported in the current work as occurring on another species of *Elymus* (*E. dahuricus* Turcz. ex Griseb.).

As with *D. agropyronophaga,* there has also been confusion concerning the publication date for *D. elymophila* (Zhang 1991). Remaudière and Remaudière (1997) listed 1990 as the date for the description but it should be regarded as 1991. See also discussion of *D. agropyronophaga* for details.

Diuraphis frequens is most similar to *D. agrostidis, D. bromicola,* and *D. holci.* Aptera and alata of *D. frequens* are distinguished from *D. agrostidis* by the absence of intersegmental sclerites, the presence of a short but elongate cornicle that is approximately equidistant between spiracles VI and VII, and the absence of a dorsal sclerite on segment VI. In *D. agrostidis,* aptera and alata exhibit intersegmental sclerites, the cornicle is porelike and situated closer to spiracle VI than VII, and a dorsal sclerite is present on segment VI. Aptera and alata of *D. frequens* are distinguished from *D. bromicola* by a short but sclerotized cornicle and the presence of a large dorsal sclerite on segment VII. In *D. bromicola,* the cornicle is porelike and unsclerotized and a large dorsal sclerite on segment VII is ab-

sent. Aptera and alata of *D. frequens* are distinguished from *D. holci* by the absence of intersegmental sclerites and antennal segment III is usually shorter than antennal segments IV + V. Conversely, *D. holci* aptera and alata exhibit intersegmental sclerites and antennal segment III is usually longer than antennal segments IV + V. See also Notes section for *D. agrostidis, D. bromicola,* and *D. holci.*

Specimens examined.—AUSTRIA: Vienna, ex grass, R. & L. Burkhart coll., USNM: 27-V-1991 (1 ap., 2 al.). CANADA: MANITOBA: St. Pierre, ex *Agropyron repens* [= *Elytrigia repens* var. *repens*], C. C. Gill coll., BMNH: 25-VIII-1965 (1 ap.); Montreal, ex *Triticum repens* [= *Elytrigia repens* var. *repens*], D.H.R.L. coll., BMNH: 21-VIII-1956 (6 ap. on 2 sl.); NEW BRUNSWICK: Fredericton, ex *Phleum pratense* (?) and *Echinochloa crus-galli,* J. B. Adams coll., BMNH: 21-VIII-1964 (7 ap. on 2 sl.). CHINA: Nei Mongol, ex *Elymus dahuricus,* IZAS: 27-VII-1984 (4 ap., 2 al.on 2 sl., one slide labeled "HOLOTYPE" and "PARATYPES") ITALY: near Udine, ex grass, R.&L. Burkhart coll., USNM: 1-VII-1991 (2 ap., 1 al.). NETHERLANDS: Bennekom, ex *Holcus* (?), H.L.G.S. coll., BMNH: 20-VI-1949 (3 ap., 1 al.); Wageningen, ex grass, D. Gonzalez coll., USNM: V-1990 (9 ap., 19 imm.). UNITED KINGDOM: ENGLAND, Tyne & Wear, Fatfield, BMNH: 31-VII-1948 (4 ap.) ;? Essex, Harlow Hill, BMNH: 28-VIII-1948 (4 ap.); Herts., Rothamsted, G. D. Heathcote coll., BMNH: 8-VI-1965 (2 al.); Middlesex, Enfield, ex grass blade, J. H. Martin, BMNH: 23-IX-1989 (6 ap.) UNITED STATES: COLORADO, Gunnison Co., Little Gunnison Cr., W. Elk Wilderness, ex *Elymus* sp., R. Hammon coll., USNM: 2-VIII-1990 (15 ap., 2 al., 27 imm. on 19 sl.); Throughline Trailhead, West Elk Wilderness, ex *Elymus glaucus,* R. Hammon and F. Judson coll., USNM: 11-VIII-1992 (2 ap., 4 imm.); Little Gunnison Creek, ex *Elymus glaucus,* F. M. Judson coll., USNM: 16-IX-1990 (8 ap. on 3 sl.); Routt Co., Rabbit Ears Pass, Ferndale Picnic Ground, ex *Elymus* sp., F. M. Judson coll., USNM: 12-VIII-1990 (4 ap., 5 al., 1 imm. on 6 sl.); NORTH DAKOTA, Fargo, ex suction trap, USNM: 29-VII-1966 (1 al.); Oregon, F. F. Hasbrouck coll., USNM: 11-VI-1953 (1 al.); WASHINGTON, Quincy, ex grass, B. J. Landis, USNM: 10-VI-1959 (1 al.); WYOMING, Fremont Co., ex quackgrass [= *Elytrigia repens* var. *repens*], C. Wilbert coll., USNM: 29-VIII-1986 (14 ap., 6 imm. on 6 sl.). UNKNOWN LOCATIONS: ex *Agropyron repens* [= *Elytrigia repens* var. *repens*], BMNH: 1-IX-1968 (3 ap., 1 imm.); "Yellow pan Trap", A. Frowd coll., USNM: 26-VI-1975 (1 al.); "yellow-trap", R. Sigvald coll., USNM: 1976 (1 al.); "trapped, USNM: no data (1 al.).

Diuraphis holci (Hille Ris Lambers)
(Fig. 7)

Aphis holci Hardy 1850:531; Hille Ris Lambers, 1956:229. *Nomen nudum.*

Holcaphis holci Hille Ris Lambers 1939: 97; Hille Ris Lambers 1956:229.

Diuraphis (Holcaphis) holci: Eastop and Hille Ris Lambers, 1976:176; Heie 1992: 104; Remaudière and Remaudière 1997: 91.

Type material.—One slide labeled cotype seen. Slide with left label "*Holcaphis holci* H.R.L. sexuales cotypes Det. D.H.R.L." and right label "N. Fd.-pl. *Holcus lanatus* Loc. Bennekom Date 3-XI-43 Leg. D.H.R.L." (BMNH).

Field features.—Aptera green with dark green head and extremities; "covered with whitish grey waxpowder" (Hille Ris Lambers 1939), cornicles and cauda brownish (Heie 1992).

Recognition characters.—*Aptera:* Body length 1.860–2.160; width through eyes 0.378–0.444. Antenna (Fig. 7A) shorter than body; segment III 0.150–0.204 long; IV 0.072–0.102 long; V 0.072–0.102 long; base of VI 0.084–0.102 long; terminal process 0.102–0.120 long. Head sclerotized,

smooth, with faint reticulate spinulation; longest dorsal head setae longer than width of antennal segment III. Rostrum extending prior to mesocoxae; ultimate segment 0.066–0.084 long, approximately 1.4–1.8 times as long as wide at base, shorter than hind tarsal segment II, without accessory setae. Pronotum without marginal tubercles. Hind tibia 0.528–0.660 long; hind tarsus II 0.108–0.138 long. Abdomen smooth with ventral surface spiculose, dorsal surface spiculose on segments VI–VIII, usually with small pleural and intersegmental sclerites, intersegmental sclerites sometimes greatly reduced, large dorsal sclerites usually present on segments VI-VIII; abdominal marginal tubercles and supracaudal process absent. Cornicle (Fig. 7B) short, 0.036–0.054 long. Cauda (Fig. 7C) 0.126–0.144 long, elongate, triangular with rounded apex, 4–6 lateral setae and 0–2 preapical setae.

Alata: Body length 1.500–1.590; width through eyes 0.333–0.372. Antenna (Fig. 7D) shorter than body; segment III 0.198–0.216 long, with 4–5 secondary sensoria restricted to approximately half circumference of segment; IV 0.078–0.096 long, with 0–1 secondary sensoria; V 0.090–0.102 long, without secondary sensoria; base of VI 0.102–0.120 long; terminal process 0.180–0.210 long. Dorsal head setae longer than width antennal segment III. Rostral length and setae similar to apterous female, ultimate segment 0.066–0.078 long, occasionally with a single accessory setae. Hind tibia 0.600–0.642 long; hind tarsus II 0.120–0.126 long. Abdominal surface sculpturing and sclerotization similar to aptera, abdominal tergite VIII with 3–5 setae; lateral abdominal tubercles and supracaudal process absent. Cornicle short, smooth, 0.034–0.049 long, similar to aptera. Cauda 0.120–0.132 long, similar to aptera.

Notes.—*Diuraphis holci* was first described as *Holcaphis holci* (Hardy) in 1939 by Hille Ris Lambers. Later, Hille Ris Lambers (1956) noted that *Aphis holci* Hardy was actually a *nomen nudum* and "should be quoted *H. holci* H.R.L., 1947." However, Hille Ris Lambers's citation of the year "1947" work was probably in error. The citation of any 1947 work mentioned by Hille Ris Lambers was not listed in the literature section in Hille Ris Lambers (1956). Examination of all of Hille Ris Lambers publications for 1947 did yield the description of *Schizaphis holci* Hille Ris Lambers (1947) that year. However, this species is not a synonym of *D. holci* and Hille Ris Lambers's (1956) reference to 1947 should be considered an error. Thus, the correct date for making the species description available is 1939.

Diuraphis holci is most similar to *D. agrostidis, D. bromicola,* and *D. frequens.* Aptera and alata of *D. holci* may be distinguished from *D. agrostidis* by intersegmental sclerites that are nearly equal or slightly smaller than the sclerotized area of the abdominal spiracles, and the presence of longer cornicles. In *D. agrostidis,* intersegmental sclerites are larger than the sclerotized area of the abdominal spiracles, and the cornicles are very small, nearly porelike. Aptera and alata of *D. holci* may be distinguished from *D. bromicola* and *D. frequens* by dorsal head setae that are longer than the widest portion of antennal segment III. The dorsal head setae in both the aptera and alata of *D. bromicola* and *D. frequens* are shorter than the greatest width of antennal segment III. In addition, aptera and alata of *D. holci* may be distinguished from *D. bromicola* by the length of hind tarsus II longer than the cauda, and the presence of pigmented cornicles. Aptera and alata of *D. bromicola* have a hind tarsus II that is shorter than the cauda, and the cornicles are unpigmented. The aptera and alata of *D. holci* may be distinguished from those of *D. frequens* by the length of hind tarsus II as compared to the caudal length and the position of the cornicle relative to adjacent spiracles. In *D. holci,* hind tarsus II is shorter than the length of the cauda and cornicle is closer to abdominal spiracle VI than VII. In *D. frequens,* hind tarsus II is longer than

the cauda and the cornicle is equidistant between abdominal spiracle VI and VII. See also the Notes section for *D. agrostidis, D. bromicola,* and *D. frequens.*

Specimens examined.—NETHERLANDS: Bennekom, ex *Holcus lanatus,* A.G. Robinson & H.R.L. coll., USNM:17-VIII-1970 (1 ap., 1 nymph). UNITED KINDOM: ENGLAND, Berkshire, Silwood Park, ex grass, J. Packham via S. McNeill coll., BMNH: 11-VII-1980 (4 al.) ; Cumberland, ex *Holcus mollis,* F.H. Jacobs coll., BMNH: 21-VII-1943 (3 ap., 9 imm.); Northumberland, Ciosforth Park, ex *Holcus mollis,* K. Muddathir coll., BMNH: 12-VII-1965 (3 al.); Welton, ex *Hordeum vulgare,* BMNH: 3-VII-1972 (2 ap., 1 nymph); Surrey, Wisley Gardens, ex? *Triticum repens,* H.L.G.S. coll., BMNH: 29-X-1954 (3 ap.); Richmond Park, ex *Holcus,* V.F.E. coll., BMNH: 19-VI-1972 (3 ap.); Kew Gardens, ex *Holcus lanatus,* V.F.E. coll., BMNH: 9-IX-1962 (5 ap.).

Diuraphis mexicana (McVicar Baker)
(Fig. 8)

Cuernavaca mexicana McVicar Baker 1934: 210.
Diuraphis mexicana: Aizenberg 1956:154.
Bracycolus nodulus Richards 1959: 251.
Diuraphis nodulus: Eastop and Hille Ris Lambers 1976:175; Peña-Martinez 1981: 178 [synonomy with *Diuraphis mexicana* (McVicar Baker)]
Diuraphis (*Diuraphis*) *mexicana*: Eastop and Hille Ris Lambers, 1976:175; Remaudière, and Remaudière 1997:91.

Type material.—Eighteen slides labeled "Cotype" deposited in USNM and listed below.

Field features.—Not recorded.

Recognition characters.—*Aptera* (Fig. 8A): Body length 1.620–1.860; width through eyes 0.372–0.414. Antenna (Fig. 8B) shorter than body; segment III 0.132–0.234 long; IV 0.078–0.126 long; base of V 0.096–0.108 long; terminal process 0.102–0.126 long. Head sclerotized, smooth, with faint reticulate spinulation; dorsal head setae blunt-tipped, longest dorsal head setae shorter than width of antennal segment III. Rostrum extending to mesocoxae; approximately 1.4–1.7 times as long as wide at base, ultimate segment 0.066–0.072 long, without accessory setae and shorter than hind tarsal segment II. Prothorax with marginal tubercles, occasionally only one present. Hind tibia 0.486–0.648 long; hind tarsus II 0.108–0.138 long. Abdomen (Fig. 8C) smooth with ventral surface spiculose, dorsal setae blunt-tipped, short; dorsal surface spiculose on segments VI–VIII, with sclerite on segments VII–VIII; slight supracaudal process (Fig. 8D) on segment VIII, deltoid shaped, process usually with a pair of lateral setae and a basal pair of setae; abdominal marginal tubercles (Fig. 8E) usually present, occasionally absent. Cornicle (Fig. 8F) short, 0.030–0.042 long, without apical flange. Cauda (Fig. 8G) 0.108–0.144 long, elongate, triangular, usually with 4 lateral setae and 0–2 preapical setae.

Alata (Fig. 8H): Body length 1.380–1.578; width through eyes 0.270–0.284. Antenna (Fig. 8I) shorter than body; segment III 0.252–0.294 long, with 4–7 secondary sensoria distributed in a straight row; IV 0.150–0.174 long, with 0–2 secondary sensoria; V 0.132–0.162 long, without secondary sensoria; base of VI 0.108–0.132 long; terminal process 0.132–0.156 long. Head setae and spinulation similar to apterous female. Rostral length and setae similar to apterous female, ultimate segment 0.060–0.072 long. Prothorax with lateral marginal tubercles, occasionally only one present. Mesosternum with rows of minute spinules; hind tibia 0.558–0.768 long; hind tarsus II 0.120–0.138 long. Wing veins with fuscous highlighting. Abdominal tergum without patches or bands, surface sculpturing similar to aptera, supracaudal process on segment VIII sometimes reduced, abdominal tergite VIII with 3–5 setae; abdominal marginal tubercles usually present, occasionally absent. Cornicle short,

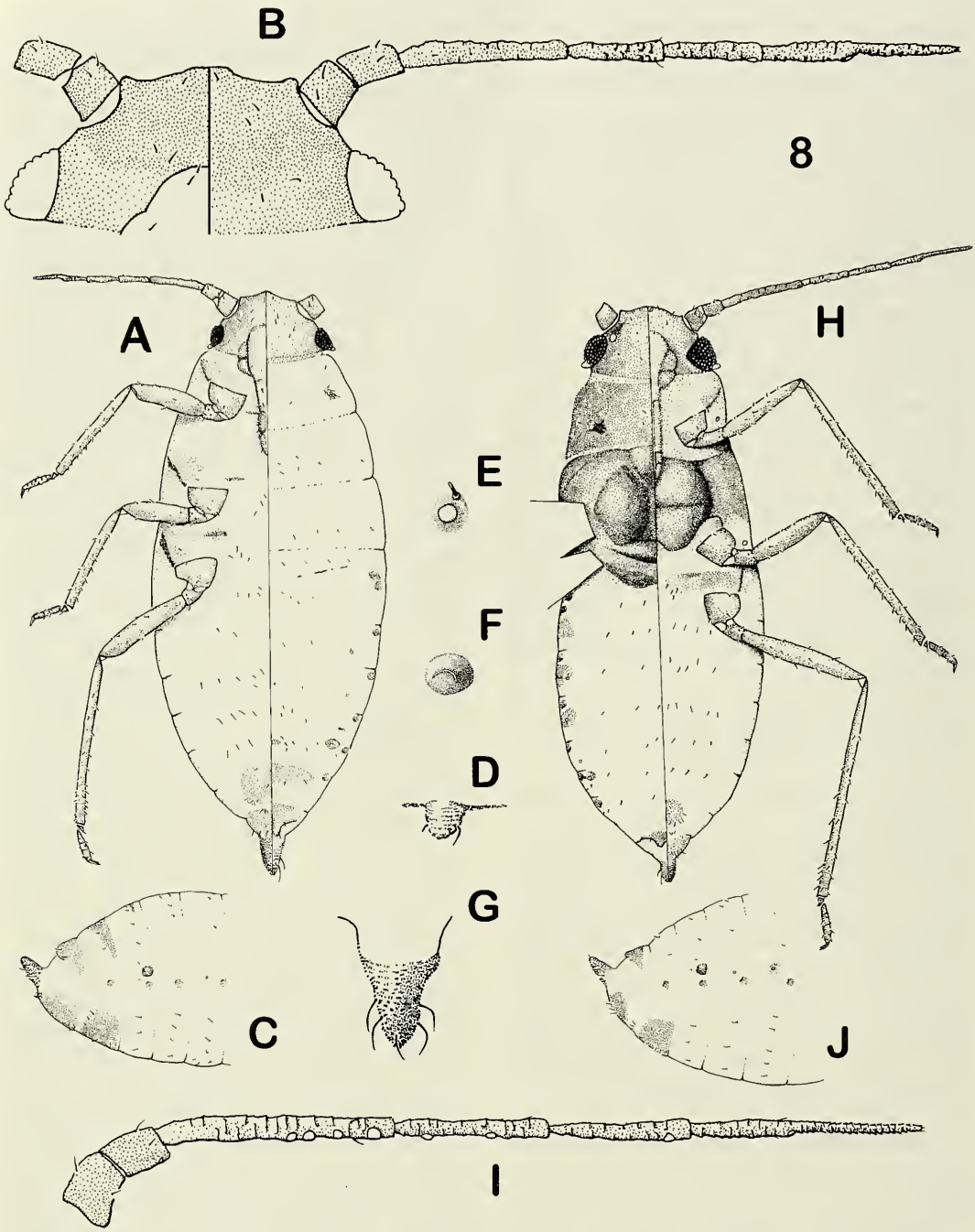


Fig. 8. *Diuraphis mexicana.* A, Aptera ventral and dorsal habitus. B, Right side, aptera dorsum of head and antennal segments; left side, aptera venter of head and antennal segments I–II. C, Aptera lateral abdominal habitus. D, Supracaudal process. E, Abdominal tubercle. F, Cornicle of aptera. G, Cauda of aptera. H, Alata dorsal and ventral habitus. I, Antenna of alata. J, Alata lateral abdominal habitus.

0.024–0.042 long, similar to aptera. Cauda 0.120–0.132 long, similar to aptera, usually with 4 lateral setae and 0–2 preapical setae.

Notes.—*Diuraphis mexicana* most closely resembles *D. noxia,* however, the supracaudal process of the aptera of *D. mexicana* is more deltoid-shaped. In *D. noxia,* this process is more fingerlike. In addition, the cornicle of *D. mexicana* does not have an apical flange whereas that of *D. noxia* does. See also Notes section of *D. noxia.*

Specimens examined.—CANADA: BRITISH COLUMBIA, Summerland, ex orchard grasses, D. P. Pielou coll., CNCI: 6-IX-1955 (2 ov., 8 al., 1 imm. on 11 sl. labeled "Holotype" and "Paratype" of *Brachycolus nodulus*); Summerland, ex downy brome [= *Bromus tectorum*], M. B. Stoetzel coll., USNM: 5-IX-1990, 7-IX-1990 (56 ap., 22 imm. on 34 sl.). MEXICO: Colonia Anáhuae, Ciudad de Mexico, ex *Bromus proximus genuinus* [?],USNM: 16-VI-1934 (10 ap., 21 al., 34 imm. on 18 sl. labeled "cotype"); Saltillo, Coahnila., ex *Bromus unioloides* [= *Bromus catharticus*], R. V. Carapia coll., USNM: 20-I-1988 (10 ap., 10 al. on 10 sl.); D.F., ENCB-IPN, ex *Bromus* sp., R. Peña coll., USNM: 14-II-1991, 1-III-1991 (42 ap., 23 al., 19 imm. on 27 sl.); Xochimilco, ex *Bromus catharticus,* Peña and Stoetzel coll., USNM: 3-IV-1991,4-IV-1991, 5-IV-1991, 6-IV-1991 (59 ap., 2 al., 93 imm. on 51 sl.); El Batan, CIMMYT- Lab colony, ex *Bromus carinatus,* M. B. Stoetzel coll., USNM: 5-IV-1991 (4 ap., 2 al., 4 imm. on 2 sl.) UNITED STATES: COLORADO, Rio Blanco Co., UCEPC-Meeker, ex *Bromus marginatus,* R. Hammon coll., USNM: 31-V-1990, 14-VI-1990, 12-IX-1991, 8-X-1991(63 ov., 82 ap., 11 al., 32 imm. of 75 sl.); Ft. Collins, CO State Univ., ex *Bromus marginatus,* W. Meyer coll., USNM: 23-XII-1991 (6 al., 3 imm. on 4 sl.); NEW MEXICO, Cimarron, R.S. Ranch, ex *Bromus polyanthus,* USNM: [no date] (31 ov., 1 ap., 5 imm. on 11 sl.); Meeker, ex mountain brome [= *Bromus marginatus*], R. W. Hammon coll., USNM: 8-14-X-1992 (30 ap., 5 ov., 6 ap. ♂, 5 imm. on 21 sl.).

Diuraphis noxia (Kurdjumov)
(Fig. 9)

Brachycolus noxius Kurdjumov 1913:13.
Diuraphis noxius: Aizenberg 1935:157.
Cavahyalopterus graminarium Mimeur 1942:67.
Brachycolus mühlei Börner 1950: 9. **New synonymy.**
Cavahyalopterus noxius: Bodenheimer and Swirski 1957:287.
Diuraphis noxia: Eastop and Hille Ris Lambers 1976:175; Dürr 1983:81; Kovalev et. al. 1991:425; Remaudière and Remaudière 1997:91.

Nomenclatural notes.—For nearly 80 years there was some confusion as to the author of *D. noxia.* Kovalev et al. (1991) provided clarification on the authorship of this species. Kurdjumov (1913) not only gave information of *D. noxia* life history and morphological characters but also developed a key for separating this species from other species of grain-damaging aphids. Mordvilko in Kurdjumov's (1913) work proposed the new epithet, *Brachycolus noxius* Mordvilko, but never published its description.

Type material.—Types of *D. noxia* not seen. Slide of *C. graminarium* labeled "paratype" (MNHN) and slide of *B. muehlei* labeled "Typen" (URIC) seen, listed below.

Field features.—Aptera green (Dürr 1983), pale yellow green, or greygreen, wax-powdered (Heie 1992); eyes reddish (Dürr 1983). Alata head dark, thorax with dark spots; abdomen pale green, not pruinose (Heie 1992).

Recognition characters.—*Aptera* (Fig. 9A): Body length 1.344–2.490; width through eyes, 0.330–0.450. Antenna (Fig. 9B) shorter than body, 6-segmented; segment III 0.096–0.192 long; IV 0.054–0.120 long; V 0.066–0.114 long; base of VI 0.060–0.102 long; terminal process 0.120–

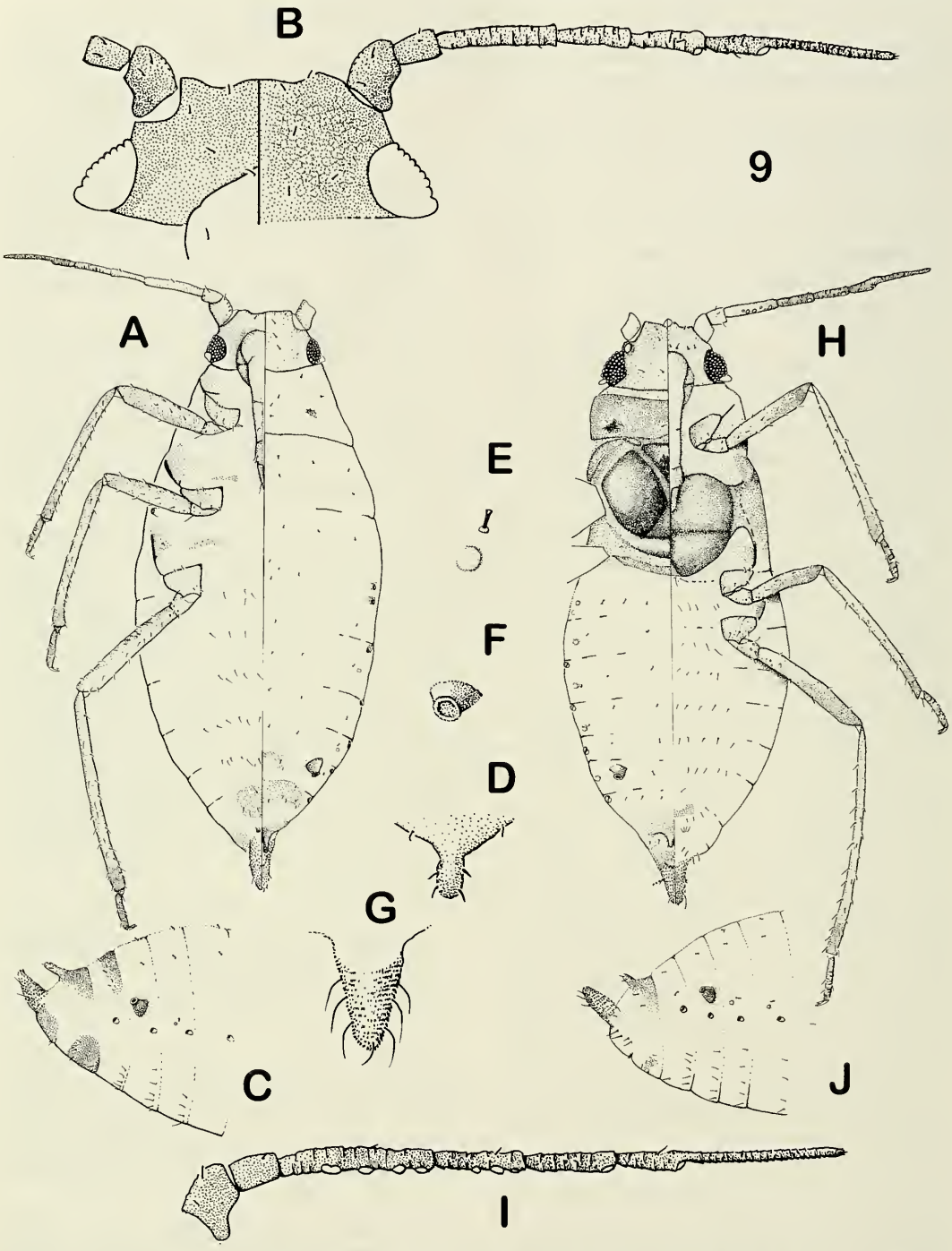


Fig. 9. *Diuraphis noxia.* A, Aptera ventral and dorsal habitus. B, Right side, aptera dorsum of head and antennal segments; left side, aptera venter of head and antennal segments I–II. C, Aptera lateral abdominal habitus. D, Supracaudal process. E, Abdominal tubercle. F, Cornicle of aptera. G, Cauda of aptera. H, Alata dorsal and ventral habitus. I, Antenna of alata. J, Alata lateral abdominal habitus.

0.180 long. Head sclerotized, smooth, occasionally with faint spinulation; dorsal head setae blunt-tipped, longest dorsal head setae shorter than width of antennal segment III. Rostrum extending to mesocoxae; ultimate segment 0.072–0.090 long, approximately 2 times as long as wide at base, without accessory setae and shorter than hind tarsal segment II. Prothorax with marginal tubercles, occasionally only one present. Hind tibia 0.402–0.678 long; hind tarsus II 0.090–0.138 long. Abdomen (Fig. 9C) smooth with ventral surface spiculose, dorsal setae blunt-tipped, short; dorsal surface spiculose on segments VII–VIII, with sclerite on segments VI–VIII; supracaudal process (Fig. 9D) on segment VIII, fingerlike, process usually with a pair of lateral setae and a basal pair of setae; abdominal marginal tubercles (Fig. 9E) present. Cornicle (Fig. 9F) short, 0.042–0.048 long. Cauda (Fig. 9G) 0.090–0.180 long, elongate, triangular, with 4–6 lateral setae and 0–2 preapical setae.

Alata (Fig. 9H): Body length 1.332–1.980; width through eyes 0 .300–0.420. Antenna (Fig. 9I) shorter than body, 6-segmented; segment III 0.126–0.198 long, with 3–7 secondary sensoria distributed in a straight row; IV 0.078–0.132 long, with 1–3 secondary sensoria; V 0.072–0.132 long, without secondary sensoria; base of VI 0.072–0.102 long; terminal process, 0.162–0.216 long. Head setae and spinulation similar to apterous female. Rostral length and setae similar to apterous female, ultimate segment 0.066–0.078 long. Prothorax with marginal tubercles, occasionally only one present. Hind tibia 0.540–0.750 long; hind tarsus II 0.102–0.132 long. Wing veins with fuscous highlighting. Abdomen (Fig. 9J) with lateral sclerites, tergum with sclerites on segments VII–VIII, surface sculpturing similar to aptera, abdominal tergite VIII with 8–10 setae including those of supracaudal process, supracaudal process on segment VIII more reduced than aptera; marginal abdominal tubercles present. Cornicle, 0.036–0.054 long, similar to aptera. Cauda 0.114–0.156 long, similar to aptera, usually with 4–6 lateral setae and 1 preapical seta.

Notes.—We place *D. muehlei* as a junior synonym of *D. noxia*. In Börner's (1950) brief original description of *D. muehlei*, he noted that it was similar to *D. noxia* but had a shorter supracaudal process on the eighth abdominal segment (¼ to ⅓ the length of the cauda versus *D. noxia* with a supracaudal process of ½ to ⅗ the length of the cauda). He also stated that *D. muehlei* caused leaf rolling in *Phleum pratense*. Differences in the ratio between the supracaudal process have been confirmed by subsequent workers since Börner's original description (e.g., Shaposhnikov 1964, Kovalev et al. 1991, Zhang et al. 1991, Heie 1992). Examination of Börner's types of *D. muehlei* revealed that the slide labeled "Typen" contained oviparae, apterous males, and immatures. While males were mentioned in the description, there was no statement concerning the stage of the adult females. Börner's use of the supracaudal-process-to-caudal-length character for species elevation is suspect. The length of the supracaudal process and the length of the cauda of this series is within his published range for *D. muehlei*. Although the supracaudal process of *D. noxia* is often half as long as or more than the caudal length, a large series of oviparae in the USNM collected from a laboratory colony revealed some specimens that exhibited a short supracaudal-process-to-caudal ratio within the range described by Börner for *D. muehlei*. Examination of the supracaudal processes for alatae and apterae from other laboratory colonies of *D. noxia* also produced individuals with a short supracaudal-process-to-caudal ratio.

Thomas Thieme (personal communication) adds important information to the *D. muehlei* story. According to Dr. Thieme, in 1944 Börner originally received specimens of *D. muehlei* from Mühle who kept the aphids in culture on *Phleum pratense*. Later, Börner received additional material and he also kept the aphids in culture. These aphids were slide mounted (also in 1944)

then described as *D. muehlei* and are represented on Börner's "Typen" slide. Subsequent workers have listed *P. pratense* as the sole host of *D. muehlei* (Shaposhnikov 1964, Kovalev et al. 1991, Zhang et al. 1991, Heie 1992). *Phleum pratense* has also been recorded as a host for *D. noxia* (Kovalev et al. 1991, Heie 1992).

Specimens examined.—AFGHANISTAN: Paghman, ex wheat, E.J. Hambleton coll., USNM: 21-VI-1961 (3 al.); Corizi-Mir, ex alfalfa, E.J. Hambleton coll., USNM: 22-VI-1961 (1 al.). ALGERIA: Belezma (Constantine), ex *Hordeum sativum* [= *Hordeum vulgare*], Frezal coll., MNHN: V-1949 (3 ap., 2 al. on 2 sl.); Kenchela, Laporte coll., MNHN: 19-III-1951 (2 al.). CANADA: BRITISH COLUMBIA, Creston, ex *Phleum pratense,* H. Gerber coll., USNM: 23-XI-1988 (1 ap.); Abbotsford, ex air suction trap, C. K. Chan coll., USNM: 8-VI-1992 (1 al.); Vancouver, ex *Agropyron,* C. K. Chan coll., USNM: 21-IX-1992 (1 ap.,1 al. on 2 sl.); 14-I-1993 (2 ap.). CHILE: Santiago, M. Zekene coll., USNM: 23-XI-1987 (2 ap., 18 al. on 10 sl.); Santiago, Crianza laboratory, M. Zerene coll., USNM: 2-V-1988 (22 ap., 4 al. on 14 sl.); Llai Llay, ex wheat, D. Reed coll., USNM: 12-XI-1990 (7 ap., 5 imm. on 8 sl.). IRAN: Karadj, ex Gramineae, G. Remaudière coll., MNHN: 12-VII-1955 (1 al.); Mashad (?), ex *Hordeum* sp., G. Remaudière coll., MNHN: 28-IX-1955 (2 ap.); Saadatabad, ex *Triticum* sp., G. Remaudière coll., MNHN: 4-V-1959 (4 ap.); 40 km E. Mashad, ex *Hordeum* sp., G. Remaudière coll., MNHN: 13-V-1966 (4 ap., 2 al. on 2 sl.); Neyshapour, 97 km. s.w. from Mashad, ex wheat, D. Gonzalez coll., USNM: 12-V-1990 (23 ap., 3 imm. on 11 sl.). ITALY: Brunico, ex *Phleum* sp., BMNH: 12-VI-1965 (2 al.). FRANCE: Perpignan (P.O.), ex *Hordeum murinum,* G. Remaudière coll., USNM: III-1971 (2 ap., 2 al.); Behoust, EPL lab colony [origins: France, Antibes, 6-VI-1989, ex wheat, K. Hopper and G. Mercadier coll.; France SE, 764–1,150 m altitude, 7-VI- 5–6-VII 1989, G. Mercadier and G. Gruber coll.; Jorden, DISI, 13-V-1989, ex wheat, K. S. Pike and L. Tanigoshi coll.; Syria, Aleppo, V-1989, ex wheat, R. Miller coll.; Turkey, Beypazari, 110 km w. Ankara, 14–19 VI 1988, ex barley, T. Paprawski and F. Gruber coll.; Moldavia, Kischenev and vicinity, 28 V- 2 VI 1989, ex wheat and barley, T. Paprawski and F. Gruber coll.; United States, South Dakota, Brookings, VIII-1988, ex wheat, N. Elliott coll.], ex barley or wheat, M. B. Stoetzel coll., USNM: 7-IX-1989 (47 ap., 35 al., 8 imm. on 24 sl.); 10-VIII-1989 (72 ap., 89 imm. on 30 sl.); 11-VIII-1989 (102 ap., 1 al., 139 imm. on 36 sl.); unknown collection date (86 ap., 33 al., 2 imm. on 58 sl.). GERMANY: ex *Phleum pratense,* Mühlei/Börner coll., URIC: 14-IV-1944 (6 ov., 1 ap. ♂, 5 imm. on 1 sl. labeled "Typen"); Leipzig, BMNH: 27-VI-1959, ex *Phleum pratense,* (2 ap., 1 al., 2 imm.). LIBYA: Tripolitania, ex wheat, Hambleton coll., USNM: 6-II-1959 (2 ap., 1 al., 1 immature on 2 sl.); 10-IV-1959 (2 ap., 2 al. on 2 sl.); Tripoli, Azizia, ex tomatoes, Hambleton coll., USNM: 4-V-1960 (3 al.); Bentmaya, Fezz-an, ex wheat, R. L. Linkfield coll., USNM: 5-IV-1962 (2 ap., 1 al., 1 immature on 2 sl.). MEXICO: Saltillo, Coah, ex *Bromus unioloides* [= *Bromus catharticus*], R. V. Carapia coll., USNM: 20-I-1988 (14 ap., 20 al. on 12 sl.); El Baton, CIMYT lab colony, ex *Bromus carinatus,* USNM: 5-IV-1991 (8 ap., 1 al., 2 imm. on 3 sl.); Xochimilco, ex *Bromus catharticus,* Peña and Stoetzel coll., USNM: 4-IV-1991 (17 ap., 1 al., 2 imm. on 8 sl.); 5-IV-1991 (1 ap., 1 al.); 6-IV-1991 (8 ap., 3 al., 3 imm. on 5 sl.). MOLDAVIA: S. Halbert coll., USNM: 6-XI-1989 (1 ap., 4 al., 38 ov., 3 ap.♂, 1 imm. on 42 sl.). MONGOLIA: Altay, D. Gonzales coll., USNM: 10-VI-1991 (18 ap., 29 imm. on 12 sl.); Wuqia, D. Gonzales coll., USNM: 3-VII-1991 (8 ap., 16 imm. on 5 sl.). MOROCCO: Rabat, ex *Triticum,* Bourleau coll., MNHN: 19-I-1939 (1 ap., 1 al. on 2 sl., labeled "paratype"). PAKISTAN: Quetta 1,800 m, ex *Triticum* sp., Inayatulla coll., MNHN: 18-III-1988 (1 ap., 1 al.). PEOPLES REPUBLIC OF CHI-

NA: Tacheng, ex wheat, D. Gonzalez coll., USNM: 28-V-1990 (14 ap., 1 al., 10 imm. on 8 sl.); Yining, ex wheat, D. Gonzalez coll., USNM: 1-VI-1990 (13 ap., 1 al., 17 imm. on 8 sl.). SOUTH AFRICA: F. du Toit coll., USNM: 20-VI-1988 (11 ap., 23 al., 11 imm. on 9 sl.); Orange Free State, Bethlehem, small grain center, F. du Toit coll., USNM: XI-1988 (23 ap., 2 imm. on 6 sl.). TURKEY: Isparta-Egridir, ex *Triticum,* Kan., Kanort., and Yesil coll., USNM: 9-V-1961 (2 ap., 2 al., 2 imm. on 9 sl.); Karaman, ex *Hordeum sativum* [= *Hordeum vulgare*], Remaudière coll., MNHN: 15-VI-1966 (1 al.); (?), ex *Triticum* sp., Remaudière coll., MNHN: 14-VI-1966 (2 ap.); Porsuk, ex wheat, M. Elmali coll., USNM: 10-VII-1990 (14 ap., 4 al. on 17 sl.); Bugday, ex wheat, M. Elmali coll., USNM: 13-VII-1990 (5 ap., 4 al. on 10 sl.). UNITED KINGDOM: (?)Lincs., Sleaford, ex *Phleum pratense,* W.H. Golightly coll., BMNH: 15-VI-1976, 21-VI-1976 (4 ap., 1 al., 3 imm. on 2 sl.); Shaffords Bridge nr. St. Albans, ex *Phleum nodosum* [= *Phleum pratense* ssp. *nodosum*], R.N.B.P coll., BMNH: 12-VIII-1956 (5 ap.).

UNITED STATES: ARIZONA, Pinal Co., Maricopa, ex wheat, D. Fullerton coll., USNM: 17-III-1987 (20 ap., 2 al., 15 imm. on 8 sl.); COLORADO, Baca Co., Springfield, ex *Triticum aestivum,* F. B. Peairs coll., USNM: 18-IV-1986 (8 ap., 1 al. and 2 imm. on 3 sl.); Waverly Co., Piedmont Farms, ex barley, USNM: 17-VIII-1990 (5 ap., 1 al. on 2 sl.); Rio Blanco Co., UCEPC-Meeker, ex wheat, R. Hammon coll., USNM: 8-X-1991 (7 ap., 1 imm. on 4 sl.); Ft. Collins, E. Prospect, ex downy brome [= *Bromus tectorum*], USNM: 17-VII-1990 (2 ap., 1 imm.); Ft. Collins [origin Weld Co., Colorado, 1988], ex wheat, USNM: 16-VII-1990 (13 ap., 6 al., 2 imm. on 7 sl.); Meeker, ex wheat, Hammon and Stoetzel coll., USNM: 18-VII-1990 (9 ap., 5 al. on 5 sl.); San Miguel Co., 3 mi w of Egnar, R. W. Hammon coll., USNM: 24-X-1995 (1 ap., 10 imm. on 3 sl.); San Miguel Co., 1 mi s of Egnar, ex wheat, R. W. Hammon coll., USNM: 8-XI-1995 (1 ap.); IDAHO, Parma [origin Caldwell, ID], Univ. of Idaho, SW ID R/E Center, M.- g. Feng coll., USNM: 27-VI-1987 (2 ap., 2 al. on 4 sl.); KANSAS, Stanton Co., ex wheat, P. E. Sloderbeck coll., USNM: 5-IV-1986 (2 ap., 2 imm.); NEW MEXICO, Eddy Co., Carlsbad, ex wheat, D. Liesner coll., USNM: 11-IV-1986 (1 ap., 1 al., 3 imm.); DeBaco Co., Ft. Summer, W. Houghton coll., USNM: 29-IV-1986 (2 ap., 2 imm.); OKLAHOMA, Cimarron Co., Boise City, ex wheat, B. Massey and S. Coppack coll., USNM: 9-IV-1986 (1 ap., 7 al., 18 imm. on 6 sl.); Stillwater [origin Texas, ex wheat, 26-III-1986], lab colony, ex winter wheat, R. L. Burton coll., USDA: 3-VII-1986 (6 ap., 7 al., 3 imm. on 7 sl.); Stillwater, lab colony, ex winter wheat, R. L. Burton coll., USNM: 19-VI-1987 (39 ap., 40 al., 48 imm. on 40 sl.); Jackson Co., nr. Altus, ex wheat, M. Karner coll., USNM: 29-III-1988 (5 ap., 2 imm. on 3 sl.); Stillwater [origin Silverton, Texas], ex barley, M. B. Stoetzel coll., USNM: 17-IV-1989 (51 ap., 56 al. on 21 sl.); Stillwater [origin Hays, Kansas], ex barley, M. B. Stoetzel coll., USNM: 20-IV-1989 (25 ap., 2 al. on 6 sl.); Stillwater [origin Ft. Collins, Colorado], ex barley, M.B. Stoetzel coll., USNM: 20-IV-1989 (51 ap., 10 al. on 12 sl.) Stillwater [origin Moscow, Idaho], ex barley, M. B. Stoetzel coll., USNM: 21-IV-1989 (25 ap., 20 al., 6 imm. on 11 sl.); OREGON, Umatilla Co., 4 mi. w. Echo, ex wheat, Reed and Stoetzel coll., USNM: 18-VI-1990 (17 ap., 18 al., 3 imm. on 11 sl.); Hermiston, M. B. Stoetzel coll., USNM: 19-VI-1990 (3 ap., 6 al., 1 imm. on 3 sl.). SOUTH DAKOTA, Jone Co., nr. Murdo, M. E. Gray coll., USNM: 10-VI-1986 (1 ap., 1 al., 1 imm.). TEXAS, Bailey Co., 18 mi SW of Muleshoe, ex wheat, E. Leach coll., USNM: 17-III-1986 (2 ap. on 2 sl.); Swisher Co., ex wheat, L. Bush coll., USNM: 20-III-1986 (3 ap., 1 al., 3 imm. on 2 sl.); Lubbock Co., 6 mi N Lubbock, ex wheat, W. P. Morrison coll., USNM: 25-III-1986 (15 ap., 1 al., 24 imm. on 11 sl.); Palmer Co., 5 mi S of Farwell, ex wheat,

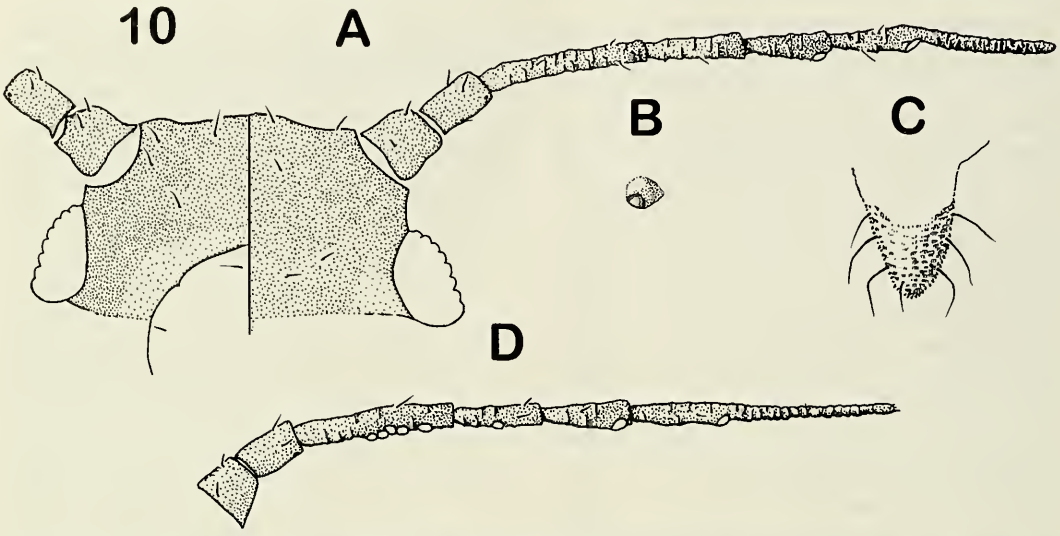


Fig. 10. *Diuraphis tritici.* A, Right side, aptera dorsum of head and antennal segments; left side, aptera venter of head and antennal segments I–II. B, Antenna of alata. C, Cornicle of aptera. D, Cauda of aptera.

W. R. Morrison coll., USNM: 26-III-1986 (2 ap., 3 al. on 3 sl.); Tom Green Co., ex wheat, T. Fuchs coll., USNM: IV-1986 (2 ap., 2 imm.); Bushland, ex wheat, Rekle coll., USNM: 28-IV-1986 (15 ap., 1 al., 11 imm. on 10 sl.); Lubbock, ex wheat, G. J. Poterka coll., USNM: 27-II-1989 (7 ap., 4 imm. on 3 sl.); Abernathy, W 1 mile on TX 597 and S 1 mile on Fm. Rd. 154, ex *Bromus willdenowii* [= *Bromus catharticus*], M. B. Stoetzel coll., USNM: 24-IV-1989 (1 ap., 5 imm. on 2 sl.); Lubbock, Lubbock Airport—U.S. 87, ex *Bromus tectorum,* M. B. Stoetzel coll., USNM: 24-IV-1989 (1 al.); Lubbock Co., U.S. 87 and TX 1294, ex *Bromus willdenowii* [= *Bromus catharticus*], M. B. Stoetzel coll., USNM: 24-IV-1989 (3 ap., 15 imm. on 3 sl.); Terry Co., Meadow, ex. *Triticum aestivum,* M. B. Stoetzel coll., USNM: 25-IV-1989 (7 ap. on 2 sl.); Swisher Co., 5 miles W Kress, Texas on TX 145, ex *Triticum aestivum,* M. B. Stoetzel coll., USNM: 26-IV-1989 (19 ap., 1 al., 5 imm. on 7 sl.); Bailey Co., ex barley in greenhouse, G. J. Puterka coll., USNM: 15-I-1990 (3 ap. on 4 sl.). WYOMING, Laramie Co., Archer Station, ex winter wheat, C. Burkhart, J. Edwards, L. Bennett coll., USNM: 2-VIII-1986 (3 ap., 7 al., 8 imm. on 5 sl.). YEMEN: Sanaá, ex wheat, D. M. Tuttle coll., USNM: 28-X-1977 (2 ap., 14 al. on 4 sl.).

Diuraphis tritici (Gillette)
(Fig. 10)

Brachycolus tritici Gillette 1911:441.
Diuraphis (*Holcaphis*) *tritici*: Eastop and Hille Ris Lambers 1976:176; Remaudière and Remaudière 1997:91.

Type material.—Since Gillette (1911) did not designate a holotype and maps drawn on the original series of slides are in error, we have selected a lectotype for clarification and to ensure stabilization of nomenclature. From the syntypes we have selected an aptera (at the 6 o'clock position) as the lectotype and have placed a label on the back of the slide with a map of the position of the specimen and the label: *Diuraphis tritici* (Gillette) LECTOTYPE & PARALECTOTYPES. The original left label and illustrated map incorrectly drawn on the front of the slide states "*Brachycolus tritici,* n. sp. Types Al. viv. Apt. viv. C. P. Gillette"; top label "U.S. Nat. Mus. Cat No 41934"; right label "on *Agropyron glaucum* 5–24–11 Ft. Collins, Colo. Coll. L. C.

Bragg Colo. Agr. Exp. Sta. Ac. 5–24–11 mt'd in xyl.balsam" (USNM). The slide also contains 2 paralectotype alatae and 1 paralectotype aptera. In addition, a single paralectoype slide containing 2 apterae and 13 imm. with original left label and illustrated map incorrectly drawn states "*Brachycolus tritici,* n. sp. Types ♀♂ others = paratypes C. P. Gillette"; top label "U.S. Nat. Mus. Cat No 41934"; right label "on wheat 10–12-'08 Ft. Collins, Colo. coll. L. C. Bragg Colo. Agr. Exp. Sta. Ac. 10–12–08 (mt'd in xyl. balsam) (USNM). This paralectoype slide has a different date ("10–12-'08") than that recorded in Gillette's (1911) description (October 10, 1908). In addition, there are no males present on the slide. However, it is possible that the discrepancy in dates may have been a typographical error. Despite these inaccuracies, we believe this slide is one of the original syntypes. A third slide labeled "COTYPE" in the USNM collection was collected in 1915, after the publication of the original description of *D. tritici,* and should not be considered a syntype.

Field features.—Aptera: covered with fine white powder, body pale green to pale yellow, cornicle color similar to body or dusky, cauda and legs dusky. Alata: body also covered with powder, cauda black; head, thorax, and most of antennae black, abdomen light green, cornicles yellow or brown (Gillette 1911).

Recognition characters.—*Aptera:* Body length 1.950–2.346; width through eyes, 0.372–0.462 Head sclerotized, smooth, with faint reticulate spinulation; longest dorsal head setae shorter than width of antennal segment III; tips of dorsal head setae blunt. Base of scape without poterior-lateral protuberance; sculpturing of anterior margin of antennal segment III differs from that of posterior margin; Antenna (Fig. 10A) shorter than body; segment III 0.120–0.228 long; IV 0.066–0.120 long; V 0.072–0.120 long; base of VI 0.072–0.096 long; terminal process, 0.090–0.156 long. Rostrum extending to meso-coxae; ultimate segment 0.126–0.144 long, approximately 3 times as long as wide at base, subequal to hind tarsal segment II, with 2 accessory setae. Pronotum without marginal tubercles. Hind tibia 0.468–0.630 long; hind tarsus II 0.120–0.150 long. Abdomen with faint fine reticulation on dorsum, surface of segments VI–VIII with additional spicules, pleural and intersegmental sclerites absent; ventral surface spiculose; abdominal marginal tubercles and supracaudal process absent. Cornicle (Fig. 10B) short, 0.012–0.036 long, apical flange undeveloped; associated basal sclerite absent. Cauda (Fig. 10C) 0.102–0.156 long, elongate, triangular with rounded apex, 4–6 lateral setae and 2 preapical setae.

Alata: Body length 1.590–1.980; width through eyes 0.318–0.408. Head spinulation less distinct and dorsal setae slightly shorter in comparison to apterous female. Antenna (Fig. 10D) shorter than body; segment III of uniform color, 0.162–0.222 long, with 4–7 secondary sensoria; IV 0.096–0.120 long, with 1–3 secondary sensoria; V 0.090–0.114 long, with 0–1 secondary sensoria; base of VI 0.090–0.102 long; terminal process 0.132–0.180 long. Rostral length and setae similar to apterous female, ultimate segment 0.120–0.144 long, with accessory setae. Pronotum without marginal tubercles. Hind tibia 0.552–0.696 long; hind tarsus II 0.126–0.150 long, imbricae usually without spinules. Abdominal surface sculpturing and sclerotization similar to aptera, abdominal marginal tubercles and supracaudal process absent. Cornicle similar to aptera; 0.012–0.030 long. Cauda 0.108–0.144 long, tapered with slight medial constriction.

Notes.—*Diuraphis tritici* can be distinguished from all other species of *Diuraphis* by its long ultimate rostral segment that has a single pair of accessory setae. It most closely resembles *D. agropyronophaga*; however, in *D. tritici* the ultimate rostral segment is approximately 3 times as long as wide at the base and the length of antennal segment III is subequal to longer than

antennal segments IV + V. In *D. agropyronophaga,* the ultimate rostral segment is approximately 2 times as long as wide at the base and the length of antennal segment III is shorter than antennal segments IV + V. See also Notes section for *D. agropyronophaga.*

Specimens examined.—CANADA: Saskatchewan, Swift Current, ex wheat, C. C. Gill, USNM: 8-VIII-1967 (1 ap.). UNITED STATES: COLORADO, Ft. Collins, ex grass, L.C.B., USNM: 31-V-1915 (2 al. on 2 sl.); Ft. Collins, Colo. Exp. Stn., ex grass, Bragg, USNM: 1-VI-1915 (6 al.); Meeker, UCEPC lab colony, ex *Bromus marginatus,* R. Hammon, USNM: 2-V-1990 (22 ap. on 9 sl.); Rio Blanco Co., UCEPC-Meeker, ex Mt. Brome "Teton, R. Hammon, USNM: 12-IX-1991 (3 ap.); Meeker, ex mountain brome [= *Bromus marginatus*], R. W. Hammon, USNM: 8-14-X-1992 (10 ap., 10 imm. on 20 sl.); KANSAS, Stanton Co., ex western wheat, K. O. Bell, USNM: 16-XI-1989 (9 ap., 17 imm. on 7 sl.); Jewell Co., ex wheat, K. O. Bell, USNM: 13-VI-1990 (5 ap.,1 imm. on 3 sl.); MINNESOTA, ex *Elymus,* USNM: 11-VII-1903 (6 ap., 14 imm.), 13-VII-1903 (9 ap., 4 al., 10 imm.); MONTANA, Judith Basin, ex wheat, S. J. Snow, USNM: 1-VI-1915 (1al., 1 imm.); Moccasin, ex wheat, J. R. Parker, USNM: 10-VI-1915 (6 al.); Bozeman, ex wheat, S. Lajeunesse, USNM: spring 1986 (2 al.); NEW MEXICO, Curry Co., Clovis, ex wheat, G. L. Nielson, USNM: 18-VI-1959 (3 ap.); Los Lunas, ex western wheat grass [= *Pascopyrum smithii*], F. Quinones, USNM: 18-V-1977 (2 ap., 2 al., 6 imm. on 3 sl.); Valencia Co., Grants, ex wheat, J. Fitzgerald, USNM: 9-V-1986 (3 ap. on 2 sl.); Clovis, ex wheat, M. Garrett, USNM: 2-V-1976 (5 ap., 11 imm. on 5 sl.); OKLAHOMA, Sentinel, ex wheat, E. Cleveland, USNM: 16-V-1974 (10 ap., 3 al., 5 imm. on 4 sl.); Stillwater, USDA-ARS lab colony [origin Boseman, Montana, ex wheat, S. Lajeunesse, spring 1986], G. Puterka, USNM: 13-II-1992 (12 ap., 12 al., on 12 sl.); SOUTH DAKOTA, Stanley Co., ex *Agropyron cristatum* and wheat, G. B. Orlob, USNM: VIII-1922 (3 ap.); TEXAS, Floydada, ex oats [= Avena sp.], USNM: 7-V-1922 (1 ap., 1 al.); Amarillo, ex wheat, N. E. Daniels, USNM: 14-III-1952 (5 ap.); WASHINGTON, Everson, ex grass, Christenson, USNM: 1-III-1941 (4 ap.); WYOMING, Platte Co., ex winter wheat, L. Bennett, C. Burkhardt, J. Edwards, USMN: 18-VI-1986 (5 ap., 7 al., 14 imm. on 5 sl.); Wheatland, ex wheat, E.G.L., USNM: no date (2 ap., 60 imm.); Ft. Collins [origin Weld Co., Colorado, 1988], ex wheat, USNM: 16-VII-1990 (13 ap., 6 al., 2 imm. on 7 sl.).

Conclusions

This generic evaluation has led to the synonymy of two species of *Diuraphis* (*D. elymophila* = *D. frequens* and *D. muehlei* = *D. noxia*). The current phylogenetic analysis also suggests that while the monophly of the subgenus *Diuraphis* (*sensu stricto*) (*D. noxia* + *D. mexicana*) is supported, the currently recognized subgenus *Holcaphis* (i.e., Eastop and Hille Ris Lambers 1976; Remaudière and Remaudière 1997) is paraphyletic. However, these findings also imply that the monophyly of *Diuraphis* (*sensu lato*) is also suspect since *B. asparagi* was included within the clade that contained *Diuraphis.* Although it was not the purpose of this paper to determine the monophyly of *Brachycolus* or *Brachycorynella,* additional studies with these groups are encouraged to determine relationships among these two genera and *Diuraphis.*

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